COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

October 1953

Aerial view of The Cleveland Electric Illuminating Company's new Eastlake Power Plant

Power for South African Synthetic Fuel Project

Future Supplies of Power

ASME Meets at Rochester

JOPPA STEAM STATION
Electric Energy, Inc.
ETIWANDA STEAM STATION
Southern California Edison Co.
PORTSMOUTH STATION
Virginia Electric and Power Co.
HENNEPIN STATION
Illinois Power Co.
LAKE CREEK STATION
Texas Power & Light Co.
MERAMEC POWER PLANT
Union Electric Co. of Missouri
AURORA STEAM ELECTRIC STATION
Minnesota Power & Light Co.

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COMBUSTION

Editorials

Rhode Island Anthracite

Periodically since its discovery in 1760, attempts have been made to utilize Rhode Island meta-anthracite as a commercial fuel, but its high ash content of thirty-five to forty per cent and its very low reactivity have combined to balk such attempts. It was unsuited to firing by hand, on stokers or in pulverized form. It has been mined on a small scale for certain uses where its graphitic nature is of some value but the demand is very limited.

The latest word on this coal is contained in a pamphlet just issued by the University of Rhode Island Experiment Station which several years ago, in conjunction with the U. S. Bureau of Mines, undertook studies and experiments looking to potential uses of this meta-anthracite such as might create a substantial demand. As reported in the pamphlet, this investigation showed the practicability of manufacturing mineral wool by changing the anthracite into a continuous-slagging type of gas producer and blowing the gas stream to make the wool.

Although the conclusions are based on pilot-plant experiments, indications are that they would be borne out on a commercial scale. The significant fact is that the product is one which is in wide demand as an insulating material and such use could readily lead to an appreciable demand for the meta-anthracite.

Instrument Clinics

Maintenance of instruments and controls assumes an ever increasing importance in steam power stations. The trend of recent years to more and more centralization of control functions continues. This means additional instruments, both of the recording and indicating types, and added interlocks of control systems. Under these circumstances uninterrupted operation of the station becomes dependent upon reliability of instruments and controls.

Instrument manufacturers have long recognized their responsibility in training skilled maintenance men. Many of them provide special training courses at their factories and at other strategically located points. Perhaps the most ambitious program is that sponsored by the Instrument Society of America. The Fifth Preconference ISA Instrument Maintenance Clinic was held in Chicago on September 18–20. Twenty-one manufacturers cooperated in presenting three simultaneous schedules, each of which covered eight types of instruments and controls. Those in attendance had the benefit of an instruction period of eighteen hours in the course of the three-day clinic.

Benefits from this training program should be forthcoming to all those who were foresighted enough to have representatives in attendance at the clinic. The Instrument Society of America and the cooperating manufacturers are to be commended for their continued sponsorship of this type of training program.

Continuous Coal Reclaiming

One of the few operations in central stations that has generally been left out of central control rooms is coal reclaiming. In the great majority of plants the functions of receiving, unloading, stocking out and reclaiming coal have been lumped together as part of work to be conducted on a single-shift, 40-hour-per-week basis. Bunkers within the plant have frequently been designed with sufficient capacity to supply maximum load from late Friday afternoon to early Monday morning.

In striving to reduce investment in building structure, the coal bunker offers an attractive place to start. At the ASME Fall Meeting in Rochester, H. C. Schweikart of Gilbert Associates described plans for coal handling at the Milliken Station of New York State Gas and Electric Corp. By designing the coal reclaiming system for continuous operation and by incorporating remote controls with indicators for the operators in the central control room, it has been possible to reduce the size of the bunker to about one third of that required in conventional design. This arrangement may prove attractive in other instances in which it is desired to minimize station building volume.

These advantages derived from continuous coal reclaiming must be balanced against the safety features of large bunkers. The latter have the merit of keeping available a larger reserve supply of coal within the station structure.

Greatest interest in the design of the coal-handling facilities of Milliken Station lies in the efforts to apply automatic features in an area where they have previously received little attention.

Power for South African Synthetic Fuel Project

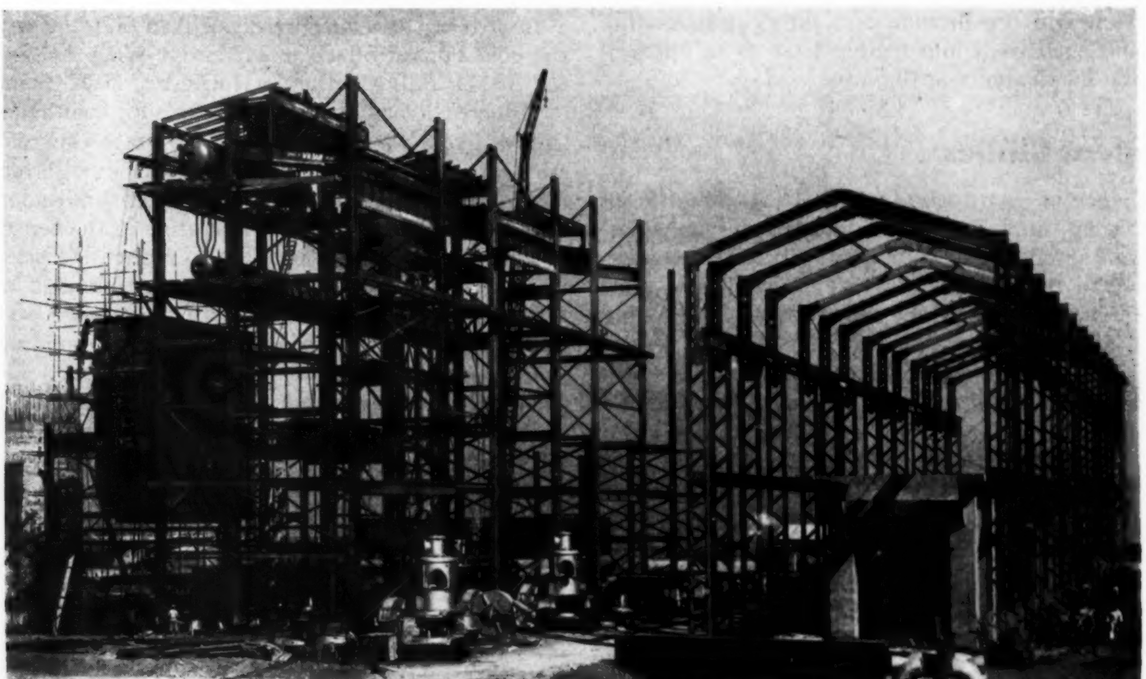
An unusual degree of international co-operation has been involved in the design and construction of the power plant for this major South African coal-to-oil project. Now under construction, it is expected to be in operation in 1954 with an initial capacity of 5400 bbl per day.

SOUTH Africa ranks second in the world with respect to the number of automobiles per inhabitant, yet it has relatively small native resources of petroleum. There are no large refineries operating in that country, although a privately owned refinery is now being built by an American oil company to process imported oil. Because of the geographical isolation of the Union of South Africa, independence of imported oil is an important element of national defense; hence a project is now well under way which will employ the abundant local coal resources for the conversion into petroleum products.

This project is being carried out by the South African Coal, Oil, and Gas Corporation (called SASOL, for short), which is an agency of the Government, and which has under construction a major oil-from-coal synthetic fuels plant, about forty miles south of Johannesburg. In the design and construction of this plant international sources of equipment supply, as well as engineering, have been drawn upon. The prime contractor and consultant for the entire undertaking is the M. W. Kellogg Company of New York; engineering for the power plant is in the hands of Societe Financiere De Transports D'Enterprise Industrielles of Brussels, Belgium (SOFINA); whereas equipment for the power plant and the refinery is being furnished by firms in South Africa, France, Switzerland, Germany, England and the United States.

This installation is expected to be in operation in 1954 and should be capable of producing about 20 per cent of South Africa's present petrol requirements. Other similar projects are under consideration. The initial capacity will be 5400 bbl of liquid product per day including alcohols, various solvents, kerosene, etc. In addition to the liquid products, fertilizer as ammonium sulfate will also be produced.

The plant is located about two miles northwest of Coalbrook Station in the districts of Vredefort and Heilbron in the Northern Orange Free State at an elevation of 4900 ft above sea level where the climate is dry and extreme temperatures range from just below freezing in July to the low nineties in January. The region has abundant coal in thick veins and, because of the proximity of the mines to the refinery, it is expected that the delivered cost of the coal will not exceed the equivalent of ninety cents a ton and may be very much less. Cal-



Progress of construction in July; boiler house to left and turbine room on right

culations show that one ton of this coal, including power requirements, will produce a barrel of oil.

Basic Elements of the Power Plant

The power plant will contain four boilers, each rated at 360,000 lb of steam per hour at 820 F and three 13,500-kw mixed-pressure turbine-generators. These will deliver power and steam for the refinery, and power to the nearby mines, a large pumping station and local communities. Under conditions of normal operation three boilers and two turbine-generators will be in service with a total steam generation of about a million pounds per hour at 550 psig. Of this amount 450,000 lb will go directly to process at high pressure for use in coal gasification. Additional steam will be supplied from waste-heat boilers operating in conjunction with the refinery.

The Vaal River from which SASOL will get its water

The main steam turbines, which are of German make, will each have an output of 10,000 kw when using high-pressure steam only; but when operated as mixed-pressure machines, with the addition of 30-lb steam from the refinery, they will be capable of producing 13,500 kw each. Also, numerous turbine drives in the refinery enter into the overall plant heat balance.

Coal from the mines is to be transported to a crushing and screening station with the fines going to the power plant, where they will be pulverized, and the remainder to process in the refinery. It is expected that around five thousand tons of coal will be converted daily into oil and allied products.

Water for the plant is taken from the Vaal River. This water is very high in dissolved solids during the rainy season. Therefore, in order to hold the solids content of that used to a reasonable value, a large storage reservoir has been built with a capacity of some fifty million gallons. The reservoir water will be blended with the river water during the season of heavy run-off. Water treatment for the plant will employ a hot-line zeolite system supplied by a British firm.

There are two circulating water systems, one for the surface condensers and the other to meet process cooling requirements. Forced-draft cooling towers are being installed.

A temporary electrical connection to the lines of the South African Electric Supply Commission will be employed for initially starting the plant.

Steam Generation Details

The boilers are of the C-E two-drum bent-tube type, designed for 650 psig and are expected to operate at 575 psig with superheater outlet temperature of 820 F at rated load of 360,000 lb of steam per hour and a feed-water inlet temperature of 230 F. They are designed to burn pulverized coal, gas or light oil, or a combination of pulverized coal and gas, as conditions from time to time may dictate.

A typical ultimate analysis of the coal to be burned is as follows:

Moisture	6.0	per cent-maximum-8.0 per cent
Carbon	51.5	per cent
Hydrogen	2.8	per cent
Oxygen	9.9	per cent
Nitrogen	1.2	per cent
Sulfur	0.73	per cent
Ash	27.9	per cent
High heating value	8,400	Btu per lb
Low heating value	8,040	Btu per lb

The coal will be pulverized in C-E Raymond bowl mills of which there are three per boiler. Each has a capacity of 25,000 lb per hr. Each furnace has three horizontal combination coal and refinery gas burners and for burning light oil, mechanical-atomizing oil guns are provided. Operation will be on fully automatic combustion control with Copes feedwater regulators. The superheaters are of the pendant type and the air heaters of the three-pass tubular counterflow type.

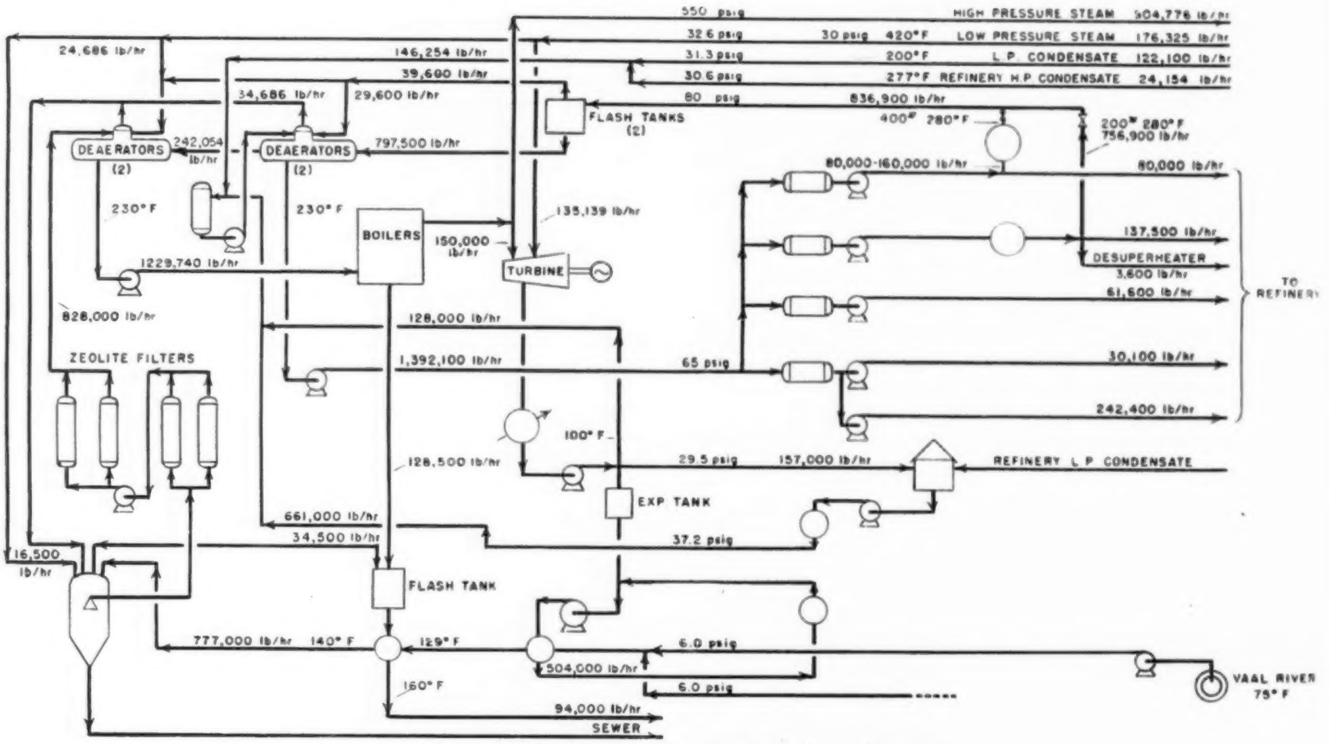
At an elevation of 5000 ft and an overload rating of 370,000 lb of steam per hour, the forced-draft fans are capable of handling 112,000 cfm at 11 in. w.g. At the same elevation and steam output, the induced-draft fans will handle 221,000 cfm at 11.85 in. w.g. The forced- and induced-draft fans are of standard American design and are furnished by the Green Fuel Economizer Co. of Beacon, New York.

The mechanical dust collectors of the Multiclone type furnished by Western Precipitation Corp., Los Angeles, are expected to have an efficiency of 85.7 per cent (based on fly ash containing not more than 28 per cent under 10 microns in size) when handling 221,000 cfm at an elevation of 5000 ft.

International Sources of Supply

In supplying the steam generators, Combustion Engineering received substantial assistance from its foreign affiliates. A subsidiary company, Combustion Engineering-Superheater Africa (Pty) Ltd., was formed to have certain material fabricated by South African industrial plants. In this way it was possible to obtain structural steel, platforms and stairways, ductwork, casings, refractory setting materials, and insulation from local sources. Motors for the bowl mills and for the forced- and induced-draft fans were supplied by Metropolitan-Vickers of South Africa.

Apart from American and South African sources, other material for the boilers was obtained from Europe. The Compagnie des Surchauffeurs of France fabricated the superheaters in general accordance with American standards. Also many of the valves were obtained from Hopkinsons Ltd. of Huddersfeld, England.



Steam, condensate and makeup flow diagram

Electrical Features

All motors over 100 hp operate at 3300 volts; those below 100 hp operate at 110, 220 or 500 volts.

As an aid in insuring continuity and reliability of electrical service, a double bus system is used throughout. Arrangements are such that power may be transferred from one bus to another in less than one second. Since the plant is isolated and has no permanent electrical interconnections, special precautions were taken to guard against all forseeable causes of forced outages.

Partial List of Other Power Equipment Supplied from Several Countries

The turbines are of AEG (German) design and manufacture.

Boiler feed pumps are supplied by Sulzer Brothers, (Switzerland) and are driven by AEG motors.

Combustion control is of Hagan design and manufacture (American).

Most of the piping will be supplied from European sources and fabricated on the job.

Allen-Sherman-Hoff is supplying a Hydrovactor for removing fly ash and a slurry system for removing ash from the boiler hopper bottoms.

Deaerating heaters will be furnished by Balke of Germany.

High-voltage switch gear is of Brown Boveri (Swiss) design.

Low voltage switch gear is from Voigt & Haefner (German).

Stacks are locally designed and fabricated.

Miscellaneous pumps are of German KSB manufacture.

Cooling towers will be supplied by the Fluor Corporation.

Surface condensers are of AEG design.

Circulating water pumps are turbine driven and supplied by KSB (German).

Carbon Dioxide in Water

Corrosion of steam condensate systems is due largely to reduction of pH of the condensate by CO_2 evolved in the boiler, according to a paper at the recent meeting of the American Chemical Society at Chicago. The paper, "Determination of Low Amounts of Carbon Dioxide in Water," by J. B. Smith, E. K. Gilbert and M. Howie of the Permutit Co. declares that analysis of condensate and boiler feedwater for total CO_2 of less than around 0.5 ppm has in the past been accomplished by direct means. The authors describe a newer method which permits determination of total CO_2 at levels of approximately 0.1 ppm. It is designed to minimize the introduction of fresh air, hence CO_2, when introducing the sample.

This method is an evolution process employing recirculated air in a closed system to strip CO_2 from a boiling acidified sample. The CO_2 is absorbed in a barium hydroxide solution, which is back-titrated with standard acid. Values obtained are compared with a blank, previously boiled, acidified distilled water.

Laboratory results on standard solutions are presented. Data obtained in the field on determination of CO_2 in the effluent from a corrosion-resistant deaerating heater treating an acid water show a value of less than 0.1 ppm. Tests on a demineralizing plant, employing a highly basic anion-exchanger, also show less than 0.1 ppm CO_2 in the effluent.

The new Fairless Works of U. S. Steel at Morrisville, Pa., which began operation last December and is expected to be completed late this year, will require some 600 railroad carloads of bituminous coal each week when operating at full capacity.

FUTURE SUPPLIES OF POWER

BY A. G. CHRISTIE

Research Professor of Mechanical Engineering
The John Hopkins University

In this paper, recently presented before the Engineering Institute of Canada at Montreal, the rapid growths in electrical load in both Canada and the United States are cited to show what may be anticipated in capacity demands by 1975. To meet these demands it is estimated that additional capital investments of 91 billion dollars in the United States and 17 billion in Canada will be required. The necessity for steam power to supplement hydro power in Canada is pointed out and the potential fuel supplies are reviewed.

STUDIES of the growth of power systems indicate that peak loads have increased over long periods at an average cumulative rate between 6 and 7 per cent per year, and peak loads double in about 11 years. There is little evidence that load saturation is near at hand. New uses for electricity are constantly developing on the farm, in homes, at factories, for electro-chemical processes, etc. These will probably maintain the present rates of load growth for many years provided no wars or economic disturbances intervene.

This rate of increase until 1975 will lead to peak loads that are four times present demands. The seriousness of the problem of future supplies becomes apparent from the need for the construction of power generating plants and distribution facilities by 1975 with capacities four times the total capacity of all present generating stations. One has only to consider the present generating capacity in electric central stations of over 80,000,000 kw[1] in the United States and of about 9,910,000 kw in Canada to realize the tremendous increases in generating plants and distribution systems that must be in operation by 1975.

Close to seven million kilowatts of new capacity was added to the power systems of the United States in 1952 at a cost of $3,700,000,000, and in Canada about 840,000 kw was added at a cost of $538,000,000. Plans call for the addition of some 11,600,000 kw of capacity in the U. S. this year and additions of 665,000 kw are said to be contemplated in Canada. While 97 per cent of the homes in the United States are electrified, the average home use is only 2175 kwhr per year which is considerably below the Canadian average. A factor in the increasing use in the home is the steady decrease in the average cost of service despite higher fuel and labor costs. In the United States this average cost decreased from 4.3 cents per kwhr in 1937 to 2.76 cents in 1952. Farm electrification is a load of increasing importance with an average use of 3075 kwhr in the United States last year.

The provision of increased capacity involves financial as well as engineering problems. The average cost of new generating plants and distribution systems in the United States over the last three years was about $380 per kw of capacity.[2] At this rate the cost of necessary additional capacity by 1975 would be about $91,200,000,000. If the same rate is assumed for Canadian steam and hydroelectric plants as noted later, and totaling 46,667,000 kw, these additions will cost $17,733,000,000 by 1975. Where are these large sums of money to be found? How can such extensions be financed without causing economic disturbances? These money problems must be solved jointly by engineers and financiers.

Some may question the high cost of future capacity. Low-cost hydroelectric sites near power-consuming centers have already been developed. The more distant sites will be expensive to exploit and will require costly transmission lines. The cost of steam stations has increased over 60 per cent during the last 20 years despite the use of large units and will probably continue to increase. Hence, the costs mentioned above can be reasonably assumed for estimating purposes.

Engineers face difficult problems in the determination of the best and most economical means of meeting these increasing power demands. Foresight is needed to estimate what sources of power may be made available, what locations should be reserved for future power sites and what distribution and interconnected systems should be planned. Steps should be taken at once to secure sites needed for future generating plants before urban development or other commercial uses prevent the acquisition of the desired areas even though the property may not be used for some years. The art of power development is changing rapidly and all plans must provide for adjustment to such changes. It is evident that engineering statesmanship is needed to guide discussions on these developments.

The Canadian Situation

Canada's industrial growth over the last decade has been amazing. The rich natural resources of the North and West are being utilized to an increasing extent. Manufacturing has become of increasing importance.

[1] Latest statistics released by the Federal Power Commission show a total installed central station capacity of approximately 84 million kilowatts plus over 15 million in industrial power plants.—EDITOR.

[2] This figure covers generating plant, transmission system and distribution.

Both population and industry may be expected to grow at an increasing rate. For these reasons, electrical demands may expand more rapidly than in the United States and the problems of future supplies of power in Canada would then become more pressing than now appears.

Canada's development of power in central electric stations has been principally at water power plants. Fortunately large capacities of hydroelectric energy are available in those sections deficient in fuel supplies. Undeveloped hydro sites lie, in general, at increasing distances from consuming centers. Transmission systems at higher voltages than now in use, can make this energy available where needed. However, construction costs will be higher for these more distant plants with long transmission lines.

Since exact data on Canadian central stations were not available to the writer, the following estimates have been based on information that was obtained from several sources.

Economic Hydro Potential

The Department of Resources and Development at Ottawa has published annual bulletins on Canadian hydroelectric progress and water-power resources. It is stated in these publications that the installed capacity in hydroelectric central stations in Canada in 1952 was 12,859,956 hp. Allowing for generator efficiency of 96 per cent, this represents about 9,210,000 kw capacity. Steam plant capacity estimated at about 700,000 kw, increases the total central station availability to 9,910,000 kw. If it is assumed that this capacity approximates present peak demands plus reserve, then 39,640,000 kw of capacity will be needed by 1975.

The Department's publications also state that the total estimated hydro capacity in Canada at ordinary minimum flow is 29,207,000 hp, or about 20,917,000 kw, and that at ordinary six months' flow turbine installations of 66,000,000 hp, or about 47,267,000 kw, are possible. Ten per cent of this capacity will probably be used by pulp and paper mills, aluminum works, mines and other industries. Also a considerable proportion of these capacities, about 10 per cent, is in northern British Columbia, northern Quebec, Newfoundland and the Northwest Territories. One may assume that only 80 per cent of these potential powers will be economically available for electric stations by 1975. Hence, possible economic hydro sites may by 1975 provide 16,734,000 kw at ordinary minimum flow and 37,814,000 kw at ordinary six months' flow. The difference between these two figures of 21,080,000 kw represents capacity available for six months only. The difference between the estimated demand in 1975, of 39,640,000 kw, and the capacity available at ordinary six months' flow of 37,814,000 kw, amounts to 1,826,000 kw and this would have to be supplied from other power sources.

Experience has shown that central electrical systems cannot render continued service based on capacities of six months' flow only. In the United States the Tennessee Valley Authority, the City of Los Angeles, the Pacific Gas and Electric Co., and power systems in the southern states, have found it necessary to supplement their hydro capacity by large steam plants. The Bonneville Power Authority is said to be considering the acquisition of coal fields in Canada to supply steam plants that must be added to their hydroelectric system to provide for low-water periods.

Hence it is reasonable to assume that some of the 21,080,000 kw available for six months only, will require supplementing by other power plants. If it is assumed that one-third of this capacity must have stand-by plants, an additional capacity of 7,027,000 kw must be provided by other than hydro.

These estimates indicate that besides the capacity of 37,814,000 kw in hydroelectric plants, a total of (1,826,000 + 7,027,000) = 8,853,000 kw capacity must be provided in other plants, the majority of which now appear to be steam plants. The enormity of Canadian power developments becomes apparent from these capacities.

Steam Power Development

Regarding Canadian fuel supplies, the coal fields of the Maritime Provinces can care for that area and also for a portion of Quebec. The Prairie Provinces have large deposits of coal, petroleum and natural gas. The two latter fuels can be made available to Ontario and Quebec by pipe lines. British Columbia also has large supplies of mineral fuels. Ontario and Quebec must depend on coal supplies from outside sources and principally from the United States. Opening of the St. Lawrence Seaway should make coal cheaper than at present at many points in these provinces as iron ore carriers would seek cargoes of coal on their down trips to Seven Islands.

District heating merits attention in connection with fuel-burning plants in Canadian cities. Winters in northern latitudes are long and cold. Older sections of the cities have deteriorated as living quarters and some are becoming slums. Reconstruction of these areas as business establishments and apartment buildings would provide a favorable situation for district heating. Air pollution would be lessened, fuel deliveries kept off the streets, and usable areas in buildings increased by the elimination of individual heating plants. As a combined result of such gains, real estate values would increase and thereby increase the city's taxable basis. The heating steam required could be generated in central electric plants at high pressures and passed through steam turbines as reducing valves into distributing pipes. The seasonal electrical energy thus developed could be delivered to the power distribution system when and as available. Such kilowatt-hours would be produced at low fuel cost.

Natural Gas and Oil

Natural gas is a premium fuel. Its greatest utility is for domestic use, certain industrial processes and petrochemical manufacture. While now used in steam power plants, from the standpoint of national economy, it should be reserved for other purposes. In the United States the price of natural gas at the wells has increased steadily and it will soon become too costly to use for steam generation. One can expect the same cost trend in Canada.

Fuel oil will become available at many centers through pipe lines from Western Canada and by tankers. Its continued use for power generation depends upon its cost which will probably increase. Where fuel oil will presently be used in steam stations, the boiler furnaces are being designed for the later use of coal.

Foresight and boldness are necessary in planning future

fuel-burning plants. The art of steam power production is changing rapidly. Only the installation of large modern high-pressure, high-temperature units will avoid early obsolescence. Low unit costs, long service life and high efficiency are best assured by such large units and by employing what may appear at the moment to be extreme steam conditions. Interconnections justify the employment of unit capacities that may appear disproportionate in size in some instances to other units on the local system.

Certain aspects of steam plant design warrant consideration. The operating availability of steam generators, turbine-generators and their several auxiliaries has increased so that power plants are now built on the unit system of "one boiler-one turbine" even in the largest sizes. Each unit has its own set of auxiliaries and there is no interconnection between units except on the outgoing electrical feeders. This design saves costly valves and piping, simplifies operation especially where reheat is used, and lowers installation cost.

Certain "Preferred Standards" for 60-cycle turbine-generators have been adopted in the United States. These cover units ranging from 12,650 kw to 150,000 kw in capacity. Non-standard single units up to 260,000 kw capacity have been purchased while units up to 500,000 kw are under discussion. All electric generators 16,500 kw and larger are hydrogen-cooled at hydrogen pressures up to 30 psi. While most of these larger units are single-shaft machines operating at 3600 rpm, some of the largest sets have two shafts with a 3600-rpm high-pressure unit and a low-pressure 1800-rpm turbine to provide sufficient exhaust areas.

Pressure Increasing

Steam pressures up to 2300 psig are in use and pressures up to 4500 psig are projected. Steam temperatures are at present limited to about 1150 F by the metals now available for superheater tubes. New metals are under development and increases in temperature may be expected. Substantial gains in fuel efficiency can be secured by employing reheat at these high pressures. The majority of large installations now have one stage of reheat.

Thermal efficiencies of steam stations have steadily improved. The average coal consumption for all utility plants in the United States which was 1.38 lb per kwhr in 1938 decreased to 1.1 lb per kw hr in 1952. Many new plants use only 0.75 lb of coal per kwhr. A recent estimate for a future plant with 3200 psig, 1150 F followed by two stages of reheat to 1100 F, is 8650 Btu per kwhr or about $^2/_3$ lb of coal of 13,300 Btu per kwhr.

Piping systems are simplified by the unit design. Steam headers and feedwater headers are eliminated and thus save many valves. Valves between the superheater outlet and turbine stop valve are left out in many cases. Piping is welded throughout.

Steam generators are of the radiant-heat type with large furnaces having heat release rates of the order of 18,000 Btu per cu ft when fired with pulverized coal. Units developing 800,000 lb of steam per hour and larger may have divided furnaces or intermediate platen groups of tubes in the upper furnace. Coal is usually burned in pulverized form. Cyclone furnaces are used with coals having low-fusing ash. Pressurized furnaces permit omission of induced-draft fans. Forced circulation will probably be employed on steam generators with pressures above 2500 psig.[3] Boiler drums are all welded and connecting tubes will probably be also welded to drums on future units. More than half the heat added to the steam is absorbed in the superheaters which are generally built in two sections. Superheat control is important at high pressures and temperatures and may be secured by attemperators, spray desuperheaters, flue gas recirculation or burner control. Besides economizers, air preheaters are added to provide air to the furnace at temperatures up to 700 F.

Available coals are becoming higher in ash content. Ash disposal areas of ample size should be provided adjacent to new plants. The public has become conscious of air pollution. Hence fuel-burning plants must be provided with mechanical or electrostatic dust catchers or both, to lessen the discharge of dust from chimneys. Sulfur cannot be removed at present from fuel or flue gases by any economic method. Increased demands for sulfur for industrial use may lead to the development of means to remove it either from the raw fuel or from the chimney gases.

Substantial savings in total plant cost have been made in southern sections of the United States by the elimination of building structures. Some northern plants have parts of the steam generator and its auxiliaries outdoors. It would seem more desirable to totally enclose Canadian plants. Such partly enclosed plants in the United States now cost from $160 to $180 per kw capacity. Lower-priced building materials are desired to lessen the cost of station structure.

Increased instrumentation is an outstanding development in steam plants. Practically all equipment is operated from a single control board or at most from two control boards. The operator secures high efficiency by interpretation of the instruments on these boards. This centralization has decreased the number of plant operators.

Working Fluids Other Than Steam

Studies have been made of the possibilities of using other working fluids than steam in power plants, but the conclusion was reached that only mercury appeared promising.

A number of plants have been built in the United States to use the mercury-steam process. Good thermal performances have been secured, the highest being about 9400 Btu per kwhr. The mercury plant is expensive to build and, as its thermal performance is being aproached by steam, it has not enjoyed wide popularity.

Diesel Engines

Diesel engines have exceptional thermal efficiencies, in the smaller sizes performances from 10,000 to 12,000 Btu per kwhr when in good operating condition. These engines burn natural gas or fuel oil, in commercial sizes up to about 3000 kw. Maintenance becomes high when low-grade fuels are used or with the employment of high brake mep. The engineers of the U. S. Rural Electrification Administration recently decided that diesel engines were best suited to plants of 10,000 kw or less in capacity. Diesels will be used largely in small isolated plants or for

[3] It has also been employed with pressures from 1450 to 2650 psig.

peak purposes at the ends of long transmission lines as well as on the railroads.

Gas Turbines

European builders have constructed the larger gas turbine sizes to date although higher gas temperatures are used in American units than in Europe. Theoretical cycles offer some interesting possibilities. However, practical difficulties with metals that must stand high temperatures, erosion by ash particles and particularly by vanadium in the ash, as well as construction of heat-exchangers, have slowed development. This promising machine will eventually find a place on power systems either alone or in combination with steam generators particularly for pipeline operation and for the smaller electric stations. Since the gas turbine gives its best performance with low-intake air temperatures, it should be particularly suitable for northern Canada.

Atomic Energy

Power production from atomic energy has been demonstrated on a laboratory scale. As now conceived, the nuclear reactor will take the place of the boiler and furnace for the generation of steam for turbine-generators. Military secrecy has prevented dissemination of information on reactor performance and no data are available. Some time may elapse before the possibilities of atomic energy for central station service can be properly appraised.

It appears from general discussions of atomic power plants that initial investment will be high. Operating costs may exceed those in present coal-fired plants if the uranium is entirely consumed but may be relatively low with breeder-type reactors or where radio-active by-products may be sold at a profit. However, some electric generating stations using atomic energy may be expected to be in service before 1975. These may influence later programs of Canadian power development.

General Considerations

It would have been impossible twenty-five years ago to predict the progress in science and engineering that are today's achievements. One is equally at a loss to predict what may occur between now and 1975. However, the importance of power in the daily life of the nation makes it obligatory upon engineers to keep abreast of all developments in science and to apply these advances where possible.

One may ask, "What pressing needs in power development demand early satisfaction?" Two appear of major importance: (*a*) greater thermal efficiency in power production and (*b*) more economic means of delivering energy to users.

Regarding thermal efficiency, while station heat rates have been reduced from 23,000 Btu per kwhr in 1914 to 9400 Btu per kwhr today, the best overall thermal efficiency is still only 36.3 per cent, largely due to the complicated cycle of burning fuel, generating steam, expanding it in a turbine and wasting much of the total heat of the fuel to the condenser cooling water. What is needed is a method to produce electrical energy directly from the combustion of the fuel by the absorption and conversion of the radiant heat and light rays emitted in the furnace. The means to effect this transformation are not known now but if discovered, would revolutionize power development.

Concerning the second need, the expense of transmitting and distributing electric energy is increasing. This is particularly true of those transmission lines at high voltage that will be needed to reach distant power sources and to provide system interconnections. Small amounts of energy have been sent short distances by wireless. Possibly directional devices of a radar nature may eventually supersede towers, insulators and transmission lines to distribute energy without wires and at lesser cost.

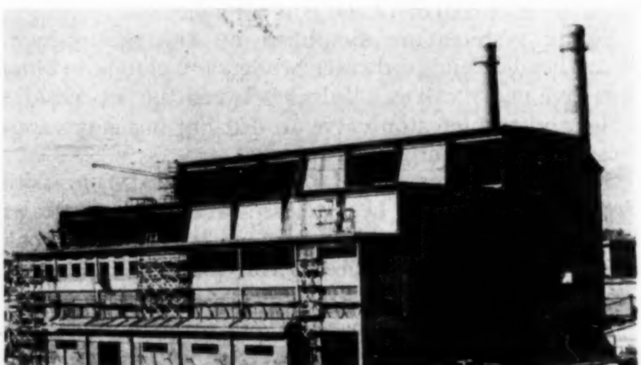
The importance of the human element in future developments cannot be overlooked. Advances in design result from the imagination and resourcefulness of engineers. Large steam power stations with automatic controls require the use of brains rather than strong backs to achieve high efficiency. The careful training of operators for such plants becomes a major consideration. College-trained men are finding increasing opportunities in the management of such stations.

Conclusions

The preceding paragraphs have presented some views on the growth of electrical loads in Canada and of the steps necessary to meet their rapidly increasing demands. Canadian engineers must design and build large steam stations in addition to many hydroelectric plants to care for load growth. Great sums of money will be required to build the necessary generating plants and distribution systems. Many more highly trained operators will be required in new plants. The task ahead is a formidable one and presents a challenge to the engineering profession of Canada. However, in view of previous accomplishments, Canadian citizens may rest assured that their engineers will provide for these future power requirements with competent means that will yield efficient results.

New Italian Plant in Service

The illustration shows the Palermo steam power plant in Sicily which has recently been completed. Built with the aid of Uncle Sam's Marshall Plan funds this station, designed and engineered by The Kuljian Corporation of Philadelphia, contains three 30,000-kw generating units. Owned and operated by Societa Termo-Elettrica Siciliana, this new power plant is counted upon to play an important role in the economic recovery of southern Italy.



Methods for Cleaning Regenerative Type Air Preheaters—Part III

By JOSEPH WAITKUS*

This is the concluding article of the series, the first and second parts of which appeared in August and September. The present article discusses the influence of certain elements in fuels that contribute to deposit formations, the effect of moisture content of the air to the forced-draft fan, and that of a wet blowing medium in accelerating corrosive action. Washing of the heating surface is described in detail.

THE subject of cleaning regenerative-type air preheaters would not be complete without a discussion of the methods for washing the heating surface to remove stubborn deposits. With the increased use of low-grade fuels high in those elements contributing to the formation of deposits and corrosion, it became increasingly important to develop further the technique of washing. Fortunately, the new cleaning devices discussed earlier lend themselves readily, without modification, to the washing operation. Some special designs have been developed which will be discussed as a part of this phase of the series of articles.

It might be well to list first some of the factors that contribute to deposit formation. According to current thinking, the following seem to be most important:

Fuel

Coal and oil are sources of trouble because of the sulfur, moisture, vanadium and ash content. Natural gas is rarely troublesome, but the mixed gaseous fuels and waste or dump fuels of various unstable and doubtful composition are known to contain some of the above elements and others of varying influence on deposit formation. These odd fuels are often heavy contributors to deposits.

Boiler Load

A load demand which fluctuates widely is likely to cause trouble when exit flue gas temperature reaches the dewpoint range. Long operating periods at low loads, combined with low-grade fuel, is an excellent combination for a corrosion and deposit problem.

Ambient Air at Forced-Draft Fan Inlet

Air admitted to the preheater, if low in temperature and/or high in entrained moisture, is recognized as another source contributing to corrosion and deposits because it lowers the metal temperature and introduces moisture. Current interest in outdoor draft fan arrangements is requiring attention to several means of control over air temperature and moisture.

Blowing Medium

A wet blowing medium will serve to support and accelerate corrosive action and will, furthermore, wash out soluble elements in the deposit, leaving the insoluble ones to produce a hard and cementlike deposit.

Some or all of the foregoing factors will be noted to exist to a certain degree in practically every installation. Variations in the individual factors or their combination makes the problem of deposit control most difficult. It explains why many installations never have to wash, whereas others have to wash as frequently as every few weeks, although the latter is rare.

The texture of the deposit cannot be overlooked in a discussion of washing procedure. It can be a dry dust varying in particle size between extremely fine to very coarse. It can be a dry and hard deposit clinging tenaciously to the metal surface. It can also be a sticky or gummy deposit appearing as almost a liquid of high viscosity. The texture is definitely under the influence of the factors listed above.

Solubility of the deposit is another point. There are very few if any deposits considered insoluble. All are soluble to a degree, depending on the composition.

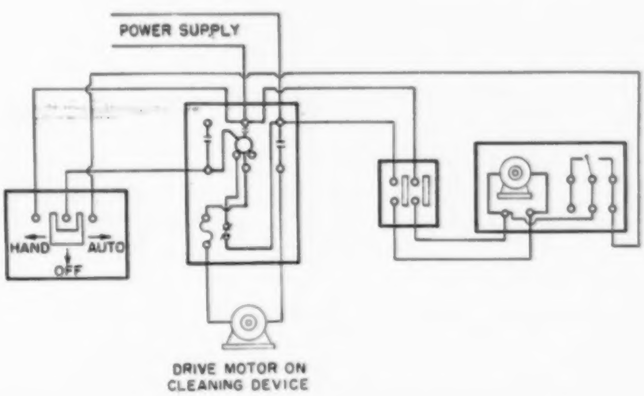


Fig. 17—Typical wiring diagram for controlled washing

Sulfates are the binder for a deposit and are highly soluble. As the binder dissolves and is removed with the washing water, it carries along with it the insoluble constituents of the deposit as a mud or sludge. If the insoluble materials are not removed and are allowed to remain on the surface, they assume the state of a cement. In such a condition they can be removed only by some mechanical action.

The rate of accumulation is also under the influence of these factors. Combined with the texture and solubility of the deposit, it determines when washing is nec-

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essary and how frequently. Obviously, the dry dust type of deposit is the ideal one. The dust is usually so fine as to be easily removed by the scrubbing effect of air and flue gas flow. It, no doubt, accounts for the installations which never have to wash and which can maintain continuous satisfactory operation by periodic use of steam or air cleaning devices. It may not even be necessary to use the cleaning device.

The sticky or gummy type of deposit is becoming quite common because of the poorer quality of the solid, liquid and mixed gaseous fuels. Under the action of the cleaning jet, which tends to roll the sticky substance instead of blowing it loose from the metal, it generally builds up rapidly to an appreciable amount deep in the surface. This type of deposit usually has a highly corrosive action on the heating surface, but frequent washing under proper conditions can neutralize the action and increase the life of the surface.

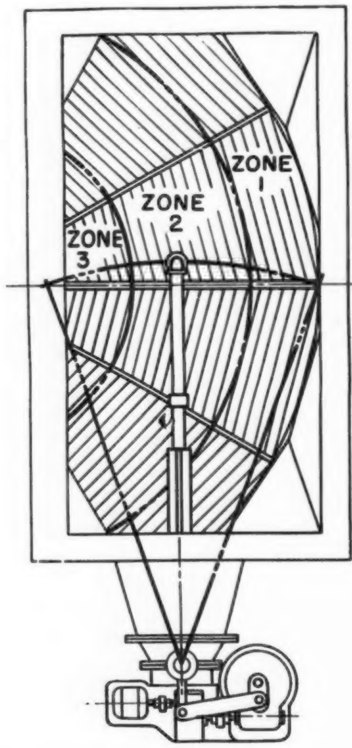


Fig. 18—Recommended zoning of rotor area to control washing with consideration for deposit density

Standard Water Requirements

Before discussing the equipment developed for washing, it might be well to touch upon the condition of the water to be used for the operation. The current standard recommendation is that the temperature be at least 150 F; the pressure be at least 10 psig for vertical units, and about 90 to 100 psig for horizontal units; the alkalinity at least 11 pH; and the quantity sufficient to assure complete removal of the deposit, approximately 130 gpm.

As for temperature, the washing will be performed quicker and the results will be better, the higher the water temperature. Some deposits will not be affected by cold water. Warm or hot water accelerates the penetration, and evaporates quickly after the washing operation is completed. When the preheater is washed with hot water soon after the equipment is shut down, there is less temperature shock to the heating surface.

Pressure is important only in connection with horizontal preheaters. Here the deposit must be moved horizontally through the depth of the surface and washed out the far end. Pressure is necessary to accomplish this. In the case of vertical units, washed from above, better results are obtained and less water is wasted, with a solid stream of water at some pressure such as will move the deposits steadily through the passages. The water trickles down through the passages in the surface to the bottom, and carries along the deposit. For vertical units washed from below, some pressure is necessary to provide sufficient penetration into the surface to assure removal of all deposits. However, washing from above should follow, and is a standard recommendation. Pressure should be adjusted to meet the needs of the type and arrangement of the preheater and the nature of deposit encountered.

The alkalinity or pH of the water has, in recent years, assumed extreme importance. By maintaining a high pH in the water the corrosive actions of the deposit and washing operations are definitely retarded. There is another significant advantage in the fact that high alkaline water seems to have a higher penetrating or wetting power. Deposits are removed more easily and with more thoroughness. Soda ash is the most common alkalizing agent because it is readily available in most plants. Caustic soda, tri-sodium phosphate and a few other agents have been used in some cases to adjust the alkalinity.

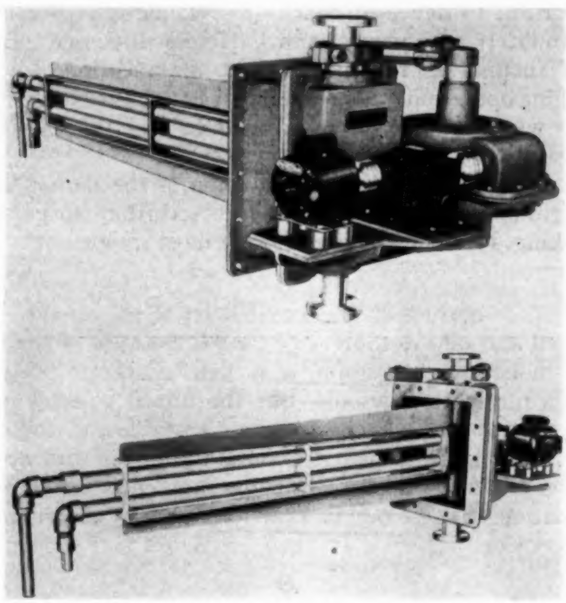


Fig. 19—Combination single-nozzle cleaning device for steam or air blowing, with water-washing nozzle included

The quantity of water to be used in the washing operation is difficult to specify, because of its dependence on several factors. Experience seems to support the suggestion that at least 75 gpm be provided, although in certain cases considerably more than this has been consumed. This may have been due to careless handling of the water or to an abundant supply with no limitations on its free use. The important point to bear in mind is to

use plenty of water as insufficient water may result in more damage and expense in the end than the cost of the water saved.

Equipment for Washing

The equipment for washing is, fortunately, very simple in design and arrangement. Since publication of the article of March 1942 in COMBUSTION, as previously

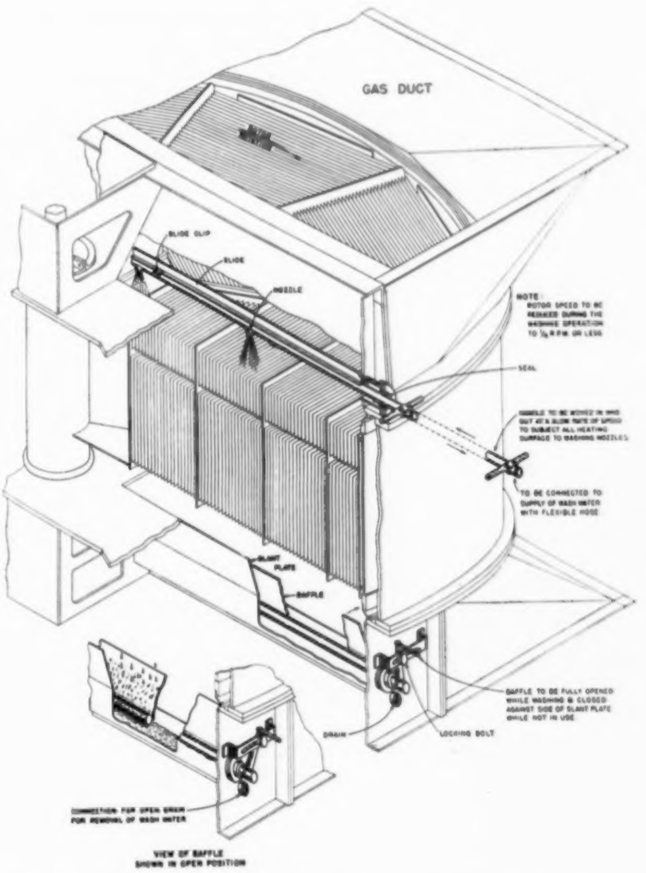


Fig. 20—Hand lance and baffle arrangement for water washing

mentioned, a few innovations have been added. As an introduction there might be listed the principal methods for washing as follows:

Hand lancing
Multi-jet spray
Single- and dual-nozzle devices

A description of the hand lance as contained in the article of March 1942 is still adequate for current needs. Supplementing it with the information and recommendations above should cover this method of washing for current practice. It is used widely, particularly as a finishing touch for the washing operation after one of the other methods is used.

The multi-spray washing arrangement is regarded today as obsolete and has been superseded by new and more effective equipment. This is not meant to imply that the multi-spray idea is no good. It has some appeal and application possibilities where there is an unlimited supply of water, or where the deposit is low in acid content and comparatively easy to remove. In other words, by practically flooding the preheater with water, the surface may be conditioned easily and quickly. The multi-spray design has been applied to horizontal preheaters with some success in a few cases. It is not being recommended generally because of the uncertainties resulting from incomplete removal of acid solutions and deposits. The cases indicating satisfactory results are usually not in the class considered as having critical operating characteristics. The multi-spray cannot be used for washing vertical units from the bottom. It is, therefore, limited to washing downward only.

With the introduction of the single- and dual-nozzle cleaning devices described earlier, it was natural to consider them for washing purposes also. In other words, the one device could serve the dual purpose of steam or air blowing and water washing. Since more efficient cleaning results were obtained by blowing with a mass jet of steam or air, it was logical to assume a better washing job might be obtained with a mass jet of water. It was only necessary to pipe water to the cleaning device and depend on the manual or power operating feature of the cleaning device to move the jet of water over the heating surface. The mass of water, with the general conditions specified, results in a concentrated scrubbing action. It tears the deposit loose and flushes it out under the force of a large quantity of water. There is less water wasted; the washing operation is very much accelerated; and the washing is more thorough.

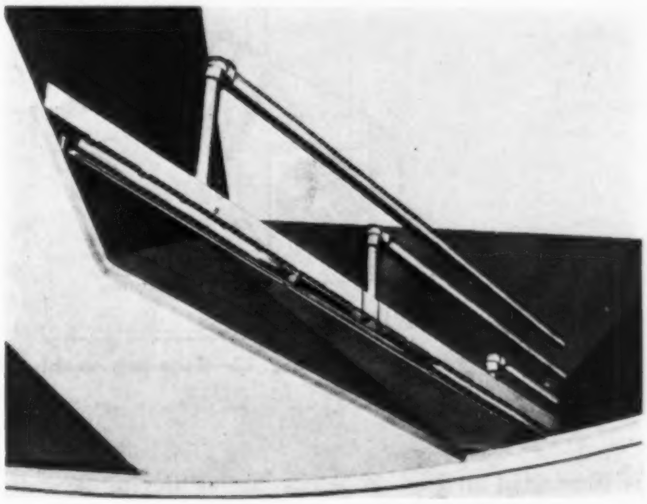


Fig. 21—Special washing arrangement with partitioned pipe and slot for distribution of water

The normal speed of rotation of the rotor in a regenerative type air preheater is approximately 3 rpm. At this speed the heating surface moves too fast for adequate washing. It is, therefore, important to synchronize the rotor speed with the movement of the water jet to assure adequate coverage of the surface and complete action on the deposits. Slowing down the rotor serves two purposes: First, it reduces the carryover of water into the adjacent duct and gives time for most of the water to drip out of the rotor into the passages where the washing operation is being conducted. Second, it gives time for a substantial quantity of water to reach into the deposit in depth and assures the removal of a larger amount of it from the surface. A reduction in rate of jet movement must follow a reduction in rotor

speed, otherwise a spiraling action will be created over the heating surface which, in turn, results in incomplete washing.

The basic idea in reducing both rotor speed and jet movement is to provide time for the water to work into the deposit and to assure that the heating surface is completely covered with effective water action.

Reducing the rotor speed was the subject of some discussion in the article of March 1942. Today the same means are being used with incidental modifications taking advantage of new design features and equipment. In other words, an auxiliary air motor, coupled to the main drive equipment for the air preheater rotor, serves adequately to reduce the speed to about $^1/_4$ rpm.

Since most cleaning devices are electrically operated, it is a simple matter to install a timing device in the circuit to energize the motor intermittently with corresponding action on the washing jet. A typical wiring diagram to suit the individual requirements of each air preheater installation.

Various nozzle designs have been studied to distribute the water more effectively over the heating surface and, furthermore to take advantage of certain nozzle characteristics which would create a washing jet with a high degree of scrubbing action. Summing up the experience of a number of installations, the conclusion reached indicates that an ordinary open-end tube of about 1-in. pipe size gave about as good results as any of the more elaborate nozzle designs. The recommended nozzle for washing, therefore, conforms to the design illustrated in Fig. 15 (September issue, Part II).

As mentioned earlier, the new cleaning devices were easily adapted to the washing operation, and in many installations independent piping systems for water and steam or air were connected to the device of single- or dual-nozzle design. In order to prevent the mixing of

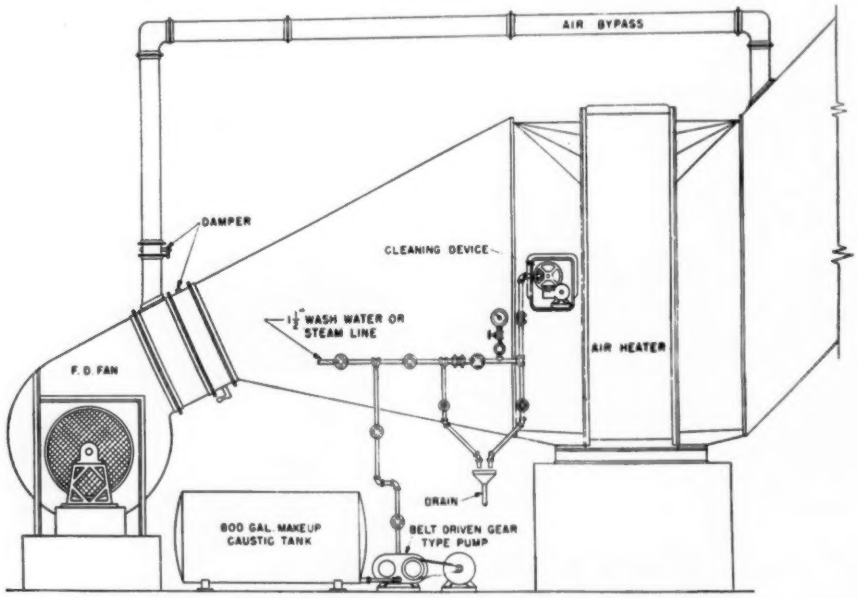


Fig. 22—Soda-ash washing arrangement with float-control

is illustrated in Fig. 17. The timing device provides a wide selection of "stop" and "start" intervals within a total time of five minutes. Continuous operation of the cleaning device is possible at any point in the course of the jet travel.

The air preheater rotor is divided into zones, as shown in Fig. 18, each zone selected with consideration for the variation in deposit density and buildup. As the washing operation is completed in each zone, the timing device is reset for the next zone. A typical timing schedule might be as follows:

Zone	Timer Setting On, Sec.	Timer Setting Off, Min.	Rotor Speed, Rpm	Washing Time
1	18	4	$^1/_4$	35 min
2	9	3	$^1/_3$	4 hrs 10 min
3	18	2	$^1/_2$	40 min
Total time one pass				5 hrs 25 min

The total time for one pass over the heating surface varies, depending on the size of the rotor and the timing schedule selected. A great deal of flexibility is available

water and steam or air, accidentally or through valve leakage, a combination single-nozzle device was developed as shown in Fig. 19. The swivel head is partitioned so that separate pipes carry water and steam or air. There is no complication in the design or arrangement, and, since it positively eliminates a source of concern in the mixing of two cleaning mediums, the combination cleaning device has been applied as standard equipment for installations anticipating washing, in addition to the normal cleaning with steam or air.

This article would not be complete without reference to several special washing devices. A unique design is illustrated in Fig. 20. It consists of two nozzles on a movable pipe positioned directly above the heating surface. By slowly moving the pipe in and out radially the water is distributed over the surface. Three or more nozzles can be provided, which causes the design to approach the multi-jet arrangement. The more jets provided, the shorter the in and out stroke of the nozzle pipe. There is the usual problem of distribution of water

to each of the nozzles and loss of pressure because of several simultaneous discharges.

Below the heating surface, a movable deflector is arranged, serving to direct the wash water into a trough from which it is drained externally to a sump or sewer. The deflector, being adjustable, is easily moved out of the position in which it might influence the flow of flue gases through the preheater.

Another recent development is illustrated in Fig. 21. It consists of a partitioned slotted pipe, each section of which is supplied with a water connection permitting distribution of the water as condition of the heating surface indicates necessary. Each section of the pipe is provided with a perforated baffle and slot which runs the full length of the section. The baffle serves to distribute the water uniformly through its perforations and creates a curtain of water through the full length of the slot.

There are other innovations and ideas too numerous to mention, but all fall into the general pattern of the designs discussed here. They are doing a satisfactory job as concerns the immediate application for which they were initially designed, but rarely have they been adapted universally or been considered satisfactory for wide application.

A question often raised when discussing the matter of alkalizing the water is "How shall it be done?" Two suggestions are offered by Figs. 22 and 23, both of which have been used with some success. The arrangement of the equipment is detailed enough in the illustrations so that further description seems hardly necessary. There are many other possible ways to provide the treatment, one of which is to use a chemical feed pulp with regulation or control to obtain the desired pH. One point not to be overlooked is to maintain close check on the pH as the washing operation progresses. By checking the water before it enters the preheater and after it leaves as a dirty effluent a good indication on the completeness of the washing operation is obtained. Washing should not be stopped until the effluent shows a pH of at least nine.

With the current practice of basketing the heating surface, particularly the cold end where deposits most generally accumulate, the recommendation is to wash outside the preheater instead of within. In other words, remove the basketed surface and wash it in a series of vats containing hot alkalized water and rinsing water which is also alkalized. In a vertical air preheater this will save the hot and intermediate layers of heating surface by not subjecting them to the acid wash water carried down from the cold end, if the cold end surface were washed while still in the rotor.

Conclusion

In closing this phase of the subject of cleaning the regenerative-type air preheater, attention might be directed to the fact that, as in the case of steam and air blowing, equipment and procedures for washing have undergone some very definite changes in the last ten years. These changes are the result of intense interest and desire to remove deposits more thoroughly, reduce corrosive action, sustain maximum recovery, reduce resistance to flow, and increase the present availability of the equipment.

The wide acceptance of the regenerative-type air preheater on steam-generating units for industrial and central station applications is in a large measure the result of the assurance this equipment offers to continuous and trouble-free operation under difficult fuel and operating conditions.

The years to follow will disclose new ideals now in the process of development. These ideas, applied to the regenerative-type air preheater, will serve to support and further elevate the efficiency of the equipment.

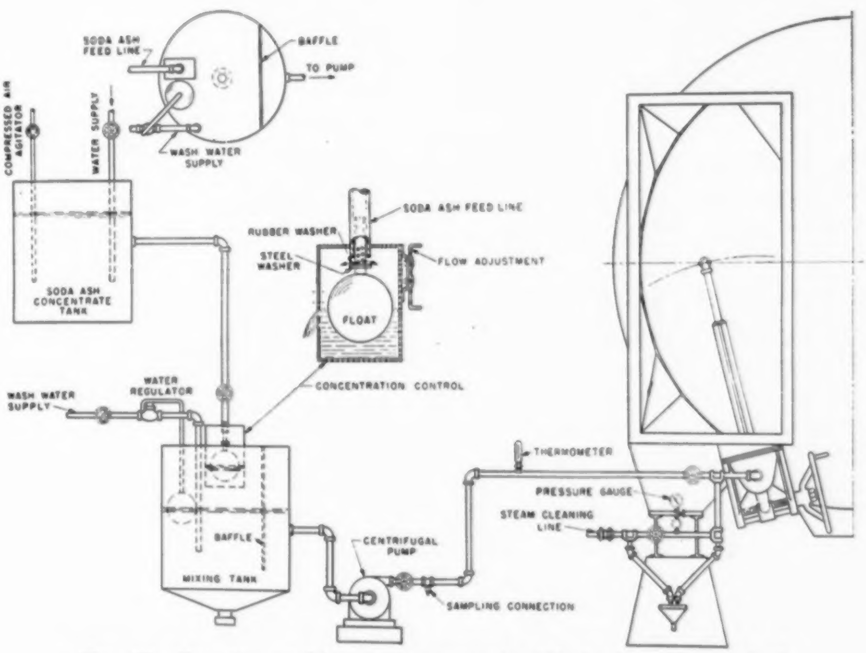


Fig. 23—Caustic washing arrangement with feed-pump control

Facts and Figures

TVA now has eleven steam plants which produce nearly half its total output.

•

Natural gas from Texas fields will be available next year in Toronto, Canada.

•

Two gallons of present-day gasoline are said to be equal in work energy to three gallons of the 1925 vintage.

•

Approximately 14 per cent of the central station electric generating capacity in the United States is federally owned.

•

On the average, of every dollar paid by the consumer for electricity over 23 cents goes into the payment of local, state and federal taxes.

•

Some seven million tons of coal are employed annually by the textile and apparel industries in the manufacture of synthetic fibers.

•

Atomic power projects now under construction, or planned, are expected to use about twenty-three million tons of coal yearly when in operation.

•

The per capita generation of electricity in the United States (central station plus industrial) is at present at the rate of approximately 3000 kwhr per year.

•

Scientists estimate that the earth's crust contains nearly twice as much nickel as it does copper, zinc and lead combined.

•

Three out of every four oil wells drilled in the United States in 1952, were drilled by small companies, individual operators or contractors.

•

More than 94 per cent of all bituminous coal produced in this country is mechanically mined and approximately 73 per cent is mechanically loaded.

•

According to a late EEI Survey, the total capacity of all central station generating units on order and scheduled for shipment, as of July 1, 1953, was 27,806,000 kw.

•

Of the present total energy requirements of the United States (stationary, mobile and residential) about 37 per cent is supplied by coal, 40 per cent by oil, 20 per cent by gas and 3 per cent by water power.

ASME Meets at Rochester

THE Fall Meeting of The American Society of Mechanical Engineers was held at the Sheraton Hotel, Rochester, N. Y., on October 5–7. The attendance taxed the capacity of that and several other hotels. A diversified program devoted to power, fuels, process industries, production, optical instruments and materials handling fitted well into the industries of that city. There were also the Calvin Rice and the Roy V. Wright lectures. Because of space limitations and primary reader interest, the following review will be devoted mainly to papers dealing with fuels and power.

Russell Station Operation

I. G. McChesney of Rochester Gas and Electric Corp. provided detailed information on design and operating experience at Russell Station. The first unit at this plant was of non-reheat design and went into service in December 1948; the second unit which operates on the reheat cycle was placed in operation in 1950; and a third unit, also incorporating reheat, is expected to go into service later this year.[1]

Unit No. 2 which has a rated capacity of 50,000 kw and a capability of 67,000 kw operates under throttle conditions of 1450 psig, 1000 F with reheat to 1000 F. For the year 1951 the average heat rate was 9935 and for 1952 it was 9990 Btu per kwhr on a net basis. The higher heat rate for 1952 was attributed to difficulties with a high-pressure heater in which a tube leak developed, necessitating the cutting out of other high-pressure heaters for a period of several weeks.

Since the plant is located in a residential district along Lake Ontario, elimination of nuisances caused by dust and noise was of considerable importance. Tests run on the electrostatic precipitator of the second unit showed an efficiency of 96 per cent at 140 per cent of rated capacity, and this rose to a value just in excess of 98 per cent at rated capacity. With continuous programmed rapping, efficiency of the precipitator is above 98 per cent in regular operation. In the early stages of operation an objectionable noise was discovered at a frequency of 238 cycles. Investigation disclosed that the forced-draft fans were the cause, and by removing the cutoff plates in these fans the intensity was reduced by three decibels near the source. The ventilator openings of the station were modified at the same time, and objectionable noise was thereby eliminated at a distance from the plant.

Precautions were taken to eliminate oxygen and other corrosive gases from the feedwater.[2] Two Kinney dry vacuum pumps were specified, each having a capacity of 4 cfm of free air with a suction pressure of one inch of mercury absolute. Reduction of ammonia in the condenser atmosphere was an important consideration in the selection of this type of pump. Power requirements are low and the pumps have proved satisfactory.

[1] For a description of the plant and a comparison of the heat cycles, see an article by Mr. McChesney which appeared in the December 1948 issue of COMBUSTION. Mr. McChesney's paper was presented by L. G. Cooley.

[2] No deaerators are installed in the feedwater cycles of this station.

The boiler feedwater pump is protected from steaming at light loads by bypassing the discharge of the pump to the condenser. To reduce erosion in the bypass line, a tube orifice is installed just downstream of the bypass control valve. After a short straight run of pipe the discharge of the orifice strikes a stainless steel baffle in a "T" fitting. A side discharge from this fitting connects with a straight pipe to the next required bend that is similarly fitted with a stainless steel target, and so on until the condenser is reached.

Power and Steam for Eastman Kodak Company

The Kodak Park power system of the Eastman Kodak Company involves a total steam capacity of 1,390,000 lb per hr, more than half of which is produced at 800 psig by four boilers and the remainder at 260 and 210 psig by eleven boilers. The total rated electrical capacity is 38,900 kw a-c and 3000 kw d-c, which is supplemented by a 9000-kw tie-line with the local utility.

The steam is used for process, heating and electric generation, the last being regarded as a by-product, although of equal importance with the steam. There is also a large refrigeration plant of 28,000 tons capacity which supplies brine and chilled water for process purposes, including air conditioning. Overall heat balance has been improved by employing condensing-turbine drives for the centrifugal refrigeration compressors that supply the air conditioning load, inasmuch as the air conditioning load occurs at the season of the peak in electric load.

In a rather detailed description of this important industrial power set-up, **H. A. Decker,** power development engineer of the Eastman Kodak Company, stated that power generation at Kodak Park dates back to 1891 although ten years previous to that Mr. Eastman had purchased his first dynamo.

A most important consideration in a photographic manufacturing plant is cleanliness, which necessitates a highly efficient air filtering system. The employment of stoker firing, for even the latest boilers, in preference to pulverized coal, was dictated, not by inability to catch fly ash and reduce stack emission to a satisfactory degree, but by the problem of removing it from the plant.

Mr. Decker stated that the annual availability factor of the 800-psig boilers and turbines is around 95 per cent and that for 1952 electric power generation amounted to 218,384,000 kwhr at an overall heat rate of 7950 Btu per kwhr, figured from the coal pile.

Precautions for Stoker-Fired Boilers

In a paper entitled "Lighting Off and Starting Up Precautions for Stoker-Fired Boilers" **H. W. Andrews** of the Kodak Park Works of Eastman Kodak Co. told of the instructions and procedures for starting up boilers at this large industrial power plant. More than 330,000 tons of coal are burned annually on underfeed and chain-grate stokers. The author gave a detailed account of the

written instructions which are issued to the operators. There are two types of multiple-retort stokers in the plant, each of which has separate instructions. A third set of instructions is issued for the chain-grate stokers.

Four of the boilers equipped with underfeed stokers operate at a pressure of 875 psig. During their outage and prior to startup the following tests are made:

1. If there has been any work on pressure parts or if gaskets have been replaced, a hydrostatic test is applied at a pressure near the safety-valve relieving point.
2. The air heater is pressure tested for leakage. Similarly, the boiler setting, economizer and air-heater casing, and air and gas ducts are tested under $2^1/_2$ in. of water pressure.
3. The stoker is operated for several hours applying maximum and minimum secondary ram stroke and link grate motion at various stoker speeds.
4. The forced and induced-draft fans are placed in operation on the combustion control system and operated throughout load range.

Ignition of coal when starting up has been by a petroleum jelly since 1949. This consists of diesel engine oil jellied with aluminum soap and avoids the housekeeping problems of maintaining wood storage bins. The petroleum jelly is more effective than wood because of its semiliquid properties in clasping the coal and is less hazardous to handle.

The paper included detailed instructions and a typical record schedule for starting up. Mr. Andrews expressed the belief that the preparation of following of such instructions has been a major factor in the complete absence of accidents during starting up.

Regenerative Type Air Preheaters

"Design and Operation of High Recovery Regenerative Air Preheaters" was the title of a paper by **George Braddon** and **Joseph Waitkus** of the Air Preheater Corporation, which was presented at the first Power Session The first part of the paper dealt with features and inherent characteristics of this type and the second part was devoted to their operation from the standpoint of removing deposits[3] and controlling metal temperature.

With the low exit gas temperatures currently being specified for high-efficiency, high-pressure steam generating units, the air preheater is assigned the task of recapturing the major share of the recoverable heat in the flue gas leaving the boiler, inasmuch as preheater surface costs less than equivalent economizer surface. Furthermore, highly preheated air contributes to reduced furnace volume because it accelerates the combustion process.

For steam generating units having capacities in excess of 300,000 lb of steam per hour, the usual practice is to provide two air preheaters, side by side; and in a few cases of very large units three have been employed.

In counterflow designs, the part where the gas enters and the air leaves is termed the "hot end" and that where the air enters and the gas leaves is the "cold end." Leakage from the high-pressure air to the lower pressure gas in a typical high-recovery regenerative air preheater is of the order of 8 per cent when the seals are properly set and in good condition.

A balanced-draft application for which about 90 per cent of the combustion air passes through the air preheater would be designed to pass the gas through approximately 60 per cent of the rotor areas and the air through 40 per cent. For pressure-fired boilers all of the combustion air, except that employed for tempering, is taken through the preheater. It would be designed to pass gas through approximately 55 per cent of the rotor area and air through the remaining 45 per cent.

Under severe operating conditions, notably those where oils of high sulfur or high vanadium content are burned, the trouble zone may extend beyond the cold layer. To cope with such conditions, an intermediate layer of heating elements of corrosion-resistant alloy can be provided.

Looking to the future, the authors expressed the hope that research may lead to means for removing solid particles from the flue gas before they come in contact with the surfaces where troublesome deposits collect; also, that successful treatments of fuels may be evolved to remove the troublesome constituents. They were of the opinion that within the next five years exit gas temperatures approaching 200 F at full load with fuels that at present cause distress may be possible.

Central Station Coal Handling

"Coal Handling Facilities for Milliken Station with Automatic Remote Control Features" was the title of a paper by **H. C. Schweikart** of Gilbert Associates, Inc. This station is a part of the New York State Electric & Gas Corp. system and is located approximately 15 miles north of Ithaca. The initial unit has a rating of 135,000 kw maximum capability, with throttle conditions of 1800 psig, 1000 F and 1000 F reheat. When burning an average quality bituminous coal originating in western Pennsylvania, Ohio or West Virginia, the steam generator will produce 1,000,000 lb of steam per hour. Four mills are provided, but three are capable of meeting requirements to pulverize 96,000 lb of fuel per hour having a grindability of 57 Hardgrove and a maximum moisture of five per cent.

As central stations have increased in size, practice in designing coal handling equipment has usually been to increase the capacities of bunkers, conveyors and feeders so as to make possible the usual intermittent, manually supervised operation confined to approximately 40 hours per week. At Milliken Station it was decided to incorporate some automatic features which would enable the reclaiming section of the coal conveying system to operate at a reduced rating as nearly continuously as possible. As a result of investigations based upon this concept of design, it was decided to build a 700-ton bunker within the station, and the author believes that this size bunker in connection with the continuous automatic reclaiming scheme will provide more active storage than a 2000-ton bunker incorporated in a conventional coal handling installation.

The bunker will be provided with four bin indicators, one above each of the four mills. These indicators will cover a range of depth of several feet with remote indications on the panelboard in the control room.

[3] Removal of deposits by washing is fully covered in the series of articles by Mr. Waitkus which are concluded in this issue of COMBUSTION, hence will be omitted from this report—EDITOR.

Coal is received at the plant by rail. For winter operation a series of 17 individual thawing pits will be provided to handle a group of three cars of any size. Unloading is by means of a car dumper, the hopper of which has two outlets each provided with a 450 ton-per-hour frozen coal cracker and apron feeder. Both feeders discharge onto a single 900 ton-per-hour belt conveyor incorporating a hinged boom at the discharge end at the yard storage area. This portion of the facilities is operated manually on an intermittent schedule.

Yard storage is made up of an inactive volume of about 500,000 tons and an active volume of 5100 tons supported over four reclaiming hoppers, each incorporating 300 ton-per-hour remote-controlled feeders. These feeders deliver coal to two crushers, and the coal leaving the latter can be discharged to either of two 300 ton-per-hour belt conveyors equipped with weighing devices. These two belts elevate the coal to a transfer point at the station where the coal is discharged to two similar belts which in turn discharge the coal directly to the bunker. This portion of the coal handling facilities is intended to operate on a continuous basis.

The purpose of this design is to provide a large active outdoor storage capacity that can be drawn upon continuously and automatically at a rate to be determined from the control room by the station operators. Coal delivery to the bunkers is expected to correspond to the actual burning rate, except for the last bunker in operation, at which point there will be some fluctuation requiring observation and adjustment of coal flow rate.

Properties of Residual Petroleum Fuels

In a paper under the above title, **W. Sacks** of McGill University, listed three types of such fuels as: (1) those containing only straight-run residua; (2) those containing only cracked residua; and (3) those containing both straight-run and cracked residua. They may be regarded as colloidal dispersions of high-molecular-weight substances in an oil medium.

As to their behavior in combustion chambers, the process of burning includes evaporation from the droplet surface followed by combustion of the vapors at a flame front surrounding the droplet, the rate of burning being dependent on the heats of combustion and vaporization rather than the fuel-vapor pressure. The droplets yield coke-like residues on combustion.

The major portion of the ash-forming constituents in residual fuels are generally vanadium, sodium, iron and nickel compounds, although considerable amounts of calcium and aluminum compounds may be present. Vanadium occurs in relatively high concentrates in fuels from Venezuelan, Arabian and certain domestic crudes. Moreover, a high vanadium content is usually associated with a high sulfur content.

The formation of sulfur trioxide from sulfur dioxide on combustion is of considerable importance because of acid corrosion by exhaust gases. Vanadium oxide is known to be an efficient catalyst in certain industrial processes and it has been suggested that such catalytic action may occur in burning residual oils. However, one investigator found no relation between sulfur-trioxide formation in a boiler and the sulfur or vanadium content of the fuel.

Centrifuging and filtering do not appear to have appreciable effect on the vanadium compounds, although they can be removed by coprecipitation with the asphaltenes using solvents. According to one recent patent, asphaltenes in residual fuels may be removed by heating with compounds such as antimony trichloride.

Usually no attempt has been made to remove these metallic constituents and serious difficulties have been encountered with ash deposition and corrosion in both boilers and gas turbines that burn residual oils containing sodium and vanadium compounds.

Turbine Starting and Loading Tests

The relation between throttle steam temperature and that in the stages of the high-pressure section of a reheat turbine is the same as in the high-pressure section of a non-reheat turbine. The temperature drop in the first stage decreases as the load is increased and consequently, during a load change, the steam temperature in the casing changes faster than throttle temperature. From the reheat admission to exhaust, the steam temperature in the turbine is a function of only the reheat temperature when the turbine is carrying load. At no load and light load the exhaust steam temperature rises because of large rotation losses in the last stages. Also, because of heat added in the reheater, the exhaust steam temperature is higher in a reheat turbine at no load. The exhaust temperature of such a machine is reduced during these conditions by water sprays in the crossover to the double-flow section. These are turned on during starting before the exhaust hood begins to heat and are shut off automatically when five per cent load is reached. Spray water is also introduced automatically when the unit is tripped or unloaded.

The foregoing basic statement formed an introduction to a paper by **E. M. Kratz** and **R. C. Wiley,** both of General Electric Company, who reported starting and loading tests made on the first 3600-rpm tandem-compound reheat turbine installed at the Dunkirk Steam Station of the Niagara Mohawk Power Corporation. This unit has a maximum capability of 100,000 kw and operates with steam conditions of 1450 psig, 1000 F at the throttle and 1000 F reheat. The high-pressure section is of the opposed-flow type with eight stages and has a double shell. The object of the test was to obtain information on operating characteristics (1) while starting and loading from turning-gear operation; (2) changing load; and (3) during tripping load and reloading. Detailed data and curves were incorporated in the paper covering each of these conditions.

The information obtained demonstrated the usefulness of metal temperature measurements to supplement other supervisory instruments and showed that maximum rates of change in metal temperatures and related thermal stresses are dependent upon the type of loading and steam temperature changes, as well as average values. The following conclusions, as concerns this turbine, were given:

1. After the unit has been off the line for a weekend, or less, it can be accelerated from turning-gear operation to 3600 rpm as fast as adequate mechanical supervision permits. The time at no load is not an important factor during subsequent loading.

2. After shutdown over a weekend, or less, the unit can be loaded at 1500 kw per minute with maximum rates of metal temperature rise of less than 500 deg F per hour.

3. Load can be changed 25 per cent of rating instantaneously and 100 per cent of rating attained at the rate of 2000 kw per minute.

4. In an emergency a load of 100,000 kw can be dumped, and reloading should be accomplished as fast as dry steam can be supplied.

ASME Codes and Standards

Addressing the President's Luncheon on the first day of the meeting, President **Frederick S. Blackall, jr.,** discussed ASME codes and standards from the standpoint of what they have accomplished. Some idea of their widespread influence may be had from the fact that they encompass some ninety different fields, and approximately three thousand engineers are contributing time and effort to more than 350 projects.

The Boiler Code is the basis of laws enacted by 20 states and 23 municipalities in this country in addition to every one of the Canadian provinces which have adopted it in whole or in part. As a result, boiler explosions with heavy toll of life and property, which were once so commonplace, are now a rarity. Hardly less important as a guardian of safety is the ASME Code for Unfired Pressure Vessels.

There is also the ASME Elevator Code which serves as a basis for laws covering the installation and operation in 17 states. For example, in New York City, with close to 22,000 elevators in the Borough of Manhattan, according to a report issued a few years ago, 97 per cent of all accidents in that year occurred on elevators installed prior to 1931, at which time the city adopted its first modern elevator code.

In the field of standards, as affecting design, interchangeability, tolerances, threads, etc., the ASME has effected savings to industry of many millions of dollars. Also, numerous manuals have been issued pertaining to recommended operating practice.

Closely related to the standards are the ASME Power Test Codes and those for Instruments and Apparatus.

In conclusion, President Blackall observed that ASME Codes and Standards save lives and dollars and in the process of their development they make better engineers of these who observe them.

The Technical Press

The annual Calvin W. Rice Lecture was delivered by **J. Foster Petree,** editor of *Engineering*, London, England, whose subject was "The Position of the Technical Press in Relation to Industry."

The speaker defined the principal function of the technical press as educational through recording progress and current events in the field covered by the particular publication; providing informed comment; preparing reviews; and giving technical advice when requested. The editor, he said, must be conversant with problems of the industry served, as well as with technical matters, and should be in a position to take definite stands without commercial considerations. However, the technical press is not always appreciated by those who benefit most.

The time lag inherent in the preparation and printing of textbooks renders many of them out of date by the time they are issued, unless they happen to cover basic matters. Therefore, readers, particularly practicing engineers, must rely upon the technical press in order to be kept abreast of current developments. Mr. Petree did not regard the technical press and engineering society papers and publications as competitive, but rather as complementary. He deprecated eye-catching devices as a means of attracting reader attention.

Mr. Petree also stressed the desirability of industrial executives personally cooperating with editors of the technical press to insure that the latter get the facts rather than delegating this function to subordinates who either may not be fully informed or who may lack authority to give the desired information.

The Engineer and Natural Resources

The speaker at the banquet was the **Hon. Robert Winters,** Canadian Minister of Resources and Development, who pointed out that the role of the engineer is basically integrated with the development and utilization of natural resources. In this connection he dealt particularly with Canada, citing that she produces 80 per cent of the world's nickel, half of its platinum, two-thirds of its asbestos and ranks second in zinc and gold output, third in silver and fourth in copper. In addition, she produces 30 per cent of the world's exported wood pulp and 80 per cent of the newsprint.

Whereas in 1946 Canada produced only about $1^1/_2$ million tons of iron annually, engineering achievements will before long raise this figure to about 30 million tons.

Discovery of oil in Alberta in 1947 has raised the oil production from barely 10 per cent of Canada's needs of less than ten years ago to at least a third of her present requirements; and with further development of oil fields in the Northwest and Yukon region she should be able to meet all her needs and perhaps be able to export some oil.

A huge aluminum undertaking in the North Coastal Mountains of British Columbia involving a number of large lakes and rivers and a ten-mile tunnel for hydro power with a 50-mile transmission line to Kitimat will lead to the production of some 500,000 metric tons of aluminum a year. This together with the Arvida project in the Province of Quebec will exceed the total output of this metal in the United States.

Furthermore in the 12 yr following the outbreak of World War II Canadian hydroelectric capacity increased 60 per cent. Her known potential hydro capacity is estimated at 66 million horsepower which includes over 8 million developable in the Yukon River Basin, the Hamilton River system in Labrador and her share of the $2^1/_2$ million horsepower at International Rapids on the St. Lawrence.

In conclusion, Mr. Winters referred to the broadened functions of the engineer and mentioned that there is now urgent need for at least an additional 2000 young engineers in Canada.

German Power Plant Operates at 1130 F*

A topping unit in the industrial power plant of Farbenfabriken Bayer at Leverkusen near Cologne, Germany, has been in service for some time with a superheater outlet steam temperature of 1130 F. The entire August 21 issue of *Zeitschrift des Vereines Deutscher Ingenieure* was devoted to this pioneering installation. The accompanying digest tells something of the plant design as well as the materials used in the Benson boiler, the radial turbine and the main steam piping. Reference is made to feedwater treatment and to boiler operating experience. After 10,000 hr of operation no boiler failures have been reported.

SINCE power on topping units can be generated with a heat rate of 4000 to 4800 Btu per kwhr operators of German industrial plants are especially interested in making use of high steam temperatures and pressures. Available topping power with a given back pressure is largely a function of primary steam pressure up to about 2000 psig. Above this point the primary steam temperature becomes the dominant factor for additional topping power. Use of reheat also makes power available when steam temperatures increase.

At the plant of Farbenfabriken Bayer in Leverkusen it was decided to use the straight-through regenerative cycle with with an initial temperature of 1130 F rather than to employ reheat at a lower temperature. The topping turbine, supplied by a boiler having a capacity of 275,000 lb of steam per hour at 2270 psig and 1130 F, operates on a back pressure of 426 psig. Steam is exhausted to an existing low-pressure turbine working against a back pressure of 85 psig. Electrical output of the two turbine generators is 19,400 kw. For the most part the plant operates on base load; at partial loads the primary steam temperature is lowered to keep the topping turbine exhaust temperature constant.

Steam Generating Unit

A Benson-type boiler was selected for the installation, one reason for the choice being that steam temperature can be lowered in a matter of minutes for continuous load without changing heating surfaces. The unit is fired tangentially by two mills when using bituminous coal or by three mills when dried brown coal is used. The furnace is of the wet bottom type and is designed for a heat release rate of 22,500 Btu per cu ft per hour and 1.36×10^6 Btu per sq ft of plain sectional area per hour. Both a Ljungstrom preheater and a plate-type air heater are installed, raising the incoming air temperature to 750 F. The feedwater enters the economizer at 390 F, passes through the slag bottom and the lower furnace walls and then flows through sections of the transition zone (evaporator), the support tubing of that surface and on to the first radiant superheater located around the middle part of the furnace. At this point there is water injection for temperature control. The steam continues through the furnace screen into the rear and front walls of the second radiant superheater covering the upper part of the furnace. Ferritic materials are used exclusively up to this section, but all following surfaces require high-alloy materials. After going through the side walls of the second radiant superheater and passing the second injection desuperheater the steam enters the final convection superheater.

Main Steam Piping

The main steam piping from the superheater outlet to the turbine is made up of a group of 28 $2^1/_2$ in. OD tubes with 0.475 in. wall thickness. This type of construction was adopted instead of a single main steam lead because of lack of experience with materials at the existing steam conditions of 2270 psig and 1130 F. At one point between the boiler and the turbine inlet, these tubes are collected into a common header forged from austenitic material with an inside diameter of $6^3/_4$ in. and a maximum wall thickness of a little more than $2^1/_2$ in. This header carries the safety valves and the turbine screen, and the intercept valve is welded to its front end. From this point the steam is carried again in subdivided tubing to the four turbine throttle valves, four tubes being connected to each turbine nozzle group by a transition piece forged and machined from solid material.

A single-flow radial-type turbine was selected. The housing is of ferritic cast steel since the steam temperature drops to 1000 F after the first stage. Strength was maintained with heavy wall thickness, and the problem of scaling in contact with high temperature steam was eliminated by calorizing the inside surface where required. After passing the intercept and throttling valves previously mentioned, the steam is admitted to the turbine at 1110 F by four nozzles, all of which are of austenitic material. The first velocity stage and the following four impulse stages have austenitic blades. By this time the steam temperature has dropped below 965 F and from this point on the usual ferritic materials are used.

Turbine Materials

The largest forged block of the turbine has a finished weight of 1450 lb and is made of steel having a composition of 16 per cent chromium, 13 per cent nickel, 1.1 per cent manganese and 1 per cent tantalum. For materials to be welded the nickel content was increased to 22 per cent, with 1.4 per cent molybdenum and 0.7 per cent vanadium. For bolts and valve spindles, the steel contains 15 per cent chromium, 35 per cent nickel with 25 per cent columbium and about 5 per cent each of molybdenum and tungsten. This material has shown excellent results so far.

Boiler and Piping Materials

In the steam generator the low alloy steel with 0.85 per cent chromium and 0.45 per cent molybdenum has sufficient strength and heat-resisting qualities up to a limit of approximately 1020 F, which corresponds to a superheater steam temperature of about 930–960 F. Among the large number of austenitic steels under consideration for temperatures above 975 F, 16 per cent chromium and 13 per cent nickel columbium-stabilized material was selected as most suitable. It was employed in the high-temperature superheaters and the main steam piping. The maximum tube temperature of about 1215 F represented the technical and economical limit at the time of the design.

With only 11 per cent of the heat supplied to the steam being in the range of above 930 F, the quantities of high alloy steel required for the boiler main steam piping and turbine amount to not more than 2 per cent of the steel requirements.

Boiler Shutdown

In order to reduce the hazard of high-temperature gradients in shutting down the steam generating unit, a special shutdown line is used in addition to the startup line. This shutdown line is connected to the unit between the transition zone (evaporator) and the superheater. With it the furnace walls, which might be heated by accumulated

* Digest prepared from a translation by W. W. Schroedter.

slag after the fire is cut off, are cooled. At the same time the superheaters and steam piping remain filled with stagnant steam and cool much slower.

Water Treatment

A series of tests was conducted to investigate the scaling behavior of ferritic and austenitic steels in contact with steam. These showed that austenitic materials stood up far better at 1290 F than ferritic material at 1020 F and that the addition of ammonia did not materially alter the results. When salts, especially those of sodium, were added to the steam, the corrosion rate increased considerably. Therefore, every effort was made to reduce the salt content of the feedwater. The makeup is obtained from a two-stage evaporator, and the solids in the primary circuit of the boiler are kept to about 0.15 ppm. This is continuously measured by several conductivity testing devices and by two special flame photometers. About 0.5 ppm of hydrazine hydrate is added for chemical deaeration and 0.2 ppm of ammonia for alkalinity control.

Performance of Materials

After an operating period of more than 10,000 hr no failures have yet occurred in the steam generator. Superheater material removed after 6400 hr showed no discernible damage inside or outside. Some specimens showed a tendency to grain decomposition which is a result of insufficient decarbonization following manufacturing.

Operating Experience

The steam generator has shown no difficulties which are connected with high-temperature operation. High efficiency has been attained in part by the use of fly-ash reinjection and maintenance of an exit gas temperature of 300 F. The slagging bottom is performing satisfactorily, giving fluid ash flow down to about 60 per cent partial load.

The turbine has operated 7000 hr with a performance somewhat less satisfactory than that of the boiler. The engine efficiency of the turbine is at the lower limit of values to be expected for topping turbines with low volume flow, though in line with those offered by manufacturers when it was ordered. The fact remains that the thermal head produced from a large financial investment is not used very effectively. An increase of turbine efficiency from 70 to 80 per cent would produce as much additional power as the increase in steam temperature from 930 to 1110 F.

It is difficult to give figures on the economics of the increase in steam temperatures because of the shifting of prices during the construction period. For a balanced price level as experienced during the summer of 1950, the additional costs would have been covered by the increased efficiency after about 11,000 hr of operation.

No final conclusions on the long-term behavior of the materials and the soundness of the design are yet possible. The austenitic material with 16 per cent chromium and 13 per cent nickel has certainly shown its merits and would be used again on another unit. Developments in new turbine steels have been pushed ahead and would now permit a steam temperature of 1200 F for the same turbine design. To advance steam conditions still further requires caution because of the corrosive effects of salts in the steam. It remains to be seen if the steam purity which can be reached practically and economically in continuous operation is sufficiently safe for further advances.

Survey Reveals Top Moneymakers in Engineering

Chemical engineers, engineers holding executive administrative positions and those engaged in contracting work are the top moneymakers of the engineering profession today. The basis for this finding is a recently completed salary and income survey conducted by a special committee of the National Society of Professional Engineers.

In the salary statistics compiled according to the specialized branches of engineering, it was revealed that the median annual income of the chemical engineers was $8910. For mining and metallurgical engineers it was $8730; for mechanical engineers, $8250; for electrical engineers, $7940; and for civil engineers, $7390. One of the reasons that civil engineers earn less than their colleagues in other specialties, the committee reported, is the fact that many of them work for government agencies, usually at the state or county level, which is a less remunerative field of employment than private industry or public utilities.

The median income for professional engineers holding executive-administrative positions, the highest paid men according to type of work performed, was reported as $9930. The median in sales work was $8370; in research and development it was $7390; in design, $7160; and in production, $6960.

When the engineers were classified by field of employment, the survey showed the median income of those working as contractors to be $9920. The figure for private practitioners was $9690; for industry employees, $8420; and for those in the field of education, $7590.

The survey, which covered more than 12,000 members of the National Society of Professional Engineers, indicated an overall median figure of $7850. The highest area median reported was $8630 for the Northeastern States, while the median salary in the Central States was $7710. Ninety per cent of the engineers replying to the salary questionnaire earned at least $5120. Twenty-five per cent earned at least $10,980, and ten per cent earned at least $17,190.

Of those who supplied the basic data, 42 per cent were civil engineers, 27 per cent were mechanical engineers and 18 per cent were electrical engineers. The survey covered the engineers' incomes for 1952, the latest full calendar year for which statistics can be supplied.

The complete report has just been published in a 28-page booklet that includes detailed statistics and charts on geographic distribution, year of entry into the profession, types of employers, branches of the profession, type of work performed, earnings by years of experience, earnings according to grades, regional variations and other data. It is available from the National Society of Professional Engineers, 1121 Fifteenth Street, N. W., Washington 5, D. C.

Personals

L. E. Morrow, executive assistant of the Rockland Light and Power Co., Nyack, N. Y., has been elected a vice president of that company with which he has been associated since 1931.

Elmer Kaiser who first engaged in coal research at Battelle in 1935 has recently been made associate director of research for Bituminous Coal Research, Inc.

Herbert G. Johnson has been elected vice president in charge of sales of The Kuljian Corporation, Philadelphia engineers and constructors.

James L. Corcoran has joined the Crosby Steam Gage & Valve Co. and The Ashton Valve Co. as director of engineering. He has been identified with safety valve engineering since 1934.

William F. Lange has been appointed to the position of assistant chief engineer of the Peabody Engineering Corp. which organization he joined in 1946 as a design engineer in the application of high pressures in the combustion of fuel oils.

Justin J. McCarthy has been appointed manager of the Philadelphia district sales office of Cochrane Corporation.

George F. Greene has been appointed assistant manager of the Service & Erection Department, in charge of erection, for Combustion Engineering, Inc. He succeeds the late James McDonnell.

Sulfuric Acid Formation in Flue Gases

My attention has been drawn to an article by Professor Torsten Widell of Stockholm on the above subject in your June 1953 issue, in which he reaches the conclusion, by a process of calculation, that the sulfur trioxide in flue gases is formed mainly in the flame at a temperature exceeding 1000 C.

Without going into the validity of the very questionable assumptions on which this article is based, may I point out that this explanation for the sulfur trioxide in flue gases, now recognized as a fundamental cause of external corrosion and deposits in boiler plants which, as you remark, is a very pressing problem throughout the world, cannot be reconciled with observed facts from operating plants.

Those of us who have had long experience in the manufacture and operation of such equipment know that:

1. Serious troubles with air-heater blockage and corrosion, and with boiler deposits, are comparatively recent in origin, having descended upon boiler plants with increasing severity only during the last twenty years. During this time plants which have been affected have suffered no fundamental change in their combustion equipment. Many boilers in this country which were built before this time are immune from such troubles or are less affected than their modern counterparts when burning the same fuel by similar means.

2. Twin-stoker-fired boilers in which the combustion equipment, furnace design, fuel and air conditions are all identical, will develop more air-heater corrosion and blockage on one side than the other and show a consistent and marked difference in the life of the air heaters serving each side, over many years of operation. This effect has been found in cases where the primary superheater is arranged at one side of the unit and the secondary superheater at the other, the worst corrosion occurring in the air heater which is in line with the highest temperature superheater.

3. Boilers with identical stokers, furnaces, economizers and air heaters, burning the same fuel, will exhibit more serious economizer troubles on those which are equipped with reheat sections than on the units without reheat.

4. Boilers will operate without air-heater blockage or corrosion for a period of over a year or more and then develop serious trouble which afterwards persists; while with other units serious difficulties with acid condensation and air-heater blockage will occur as soon as they are placed in commission, but this will sometimes diminish and become tolerable without any modification

(*Continued on page 63*)

being made to the fuel or combustion conditions.

The theory advanced by Professor Widell and others that the sulfur trioxide formation is an inherent feature of the conbustion process cannot explain these well-established facts.

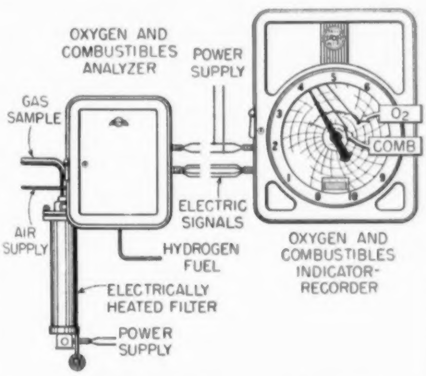
The laws of nature governing the formation of sulfur trioxide have not changed in the twenty years or so during which these troubles have developed; neither can they change during the operating life of a boiler. Other factors must be taken into account if the true cause of this occurrence is to be determined and the difficulties removed.

W. F. HARLOW
Special Director
International Combustion, Ltd.
Derby, England

New Equipment

Oxygen and Combustibles Analyzer

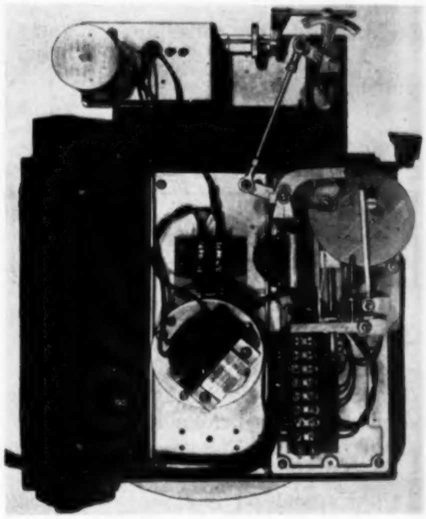
Bailey Meter Co., 1050 Ivanhoe Road, Cleveland 10, Ohio, has developed a combination oxygen and combustibles analyzer which provides vital operating information on combustion performance. This gas analyzer is capable of saving fuel, especially where multi-fuels or fuels of varying composition are fired, and acts as a safety guide to prevent the lighting off of unpurged, gas-fired combustion chambers. Analyses of per cent



oxygen (an index of excess air) and per cent combustible (an index of fuel-air mixing performance) are offered for the first time in a single, compact unit. The gas analyzer and its recorder indicate or automatically control the necessary adjustments required to maintain maximum combustion efficiency within combustion equipment limitations. It has the following characteristics: minimum range, 0–5 per cent; maximum range, 0–25 per cent; uses compressed air and hydrogen for catalytic combustion; noble metal filaments with thermal conductivity compensators are part of null balance bridges; accurate within ±0.25 per cent by volume of oxygen and combustibles contents in sample.

Flowmeter

A flowmeter of the electronic type which makes use of mercury-less bellows type transmitters has been announced by the Hays Corp., Michigan City, Ind. This meter is available in several different models for indicating, recording and with a continuous type mechanical integrator or combinations thereof for measurement of the flow of fluids such as steam, water and other fluids and gases. Records of air flow for boiler operation and pressures and temperatures can be combined in the same meter. The differential pressure transmitters used with the meter are of the metallic bellows, rupture-proof type for differentials of from 20 to 750 in. water with a standard static operating pressure of 1500 psig. Higher pressure ratings can be supplied if required. The meter is also available for the measurement of liquid level in an enclosed vessel such as a boiler drum. An electronic amplifier in the circuit of the meter assures maximum sensitivity and a great speed of response.

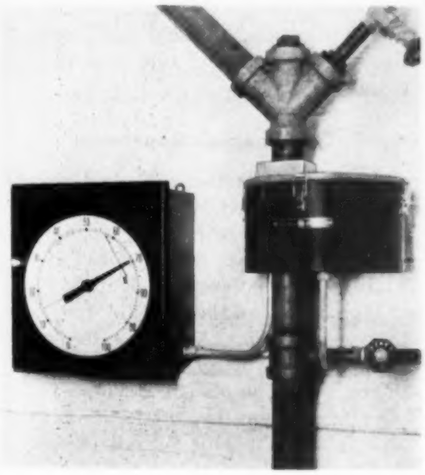


Packaged Dust Collector

A package smoke and fume control unit has been developed by Robert E. Moyer Associates, Catasauqua, Penna. The unit incorporates dry dust collection, odor removing catalyst and scrubbing equipment complete with induced draft fan and water pumping equipment, all integrally connected. Removal of dust concentrations up to 100 grains per cu ft of gas can be expected for the unit, which uses a catalyst arrangement to remove odors produced by burning rubber, refuse, etc., and a scrubber that also reduces the exit temperature. The unit can be supplied in various sizes and can be adapted to existing or standard equipment.

Recording Turbidimeter

A new recording turbidimeter, which continuously and automatically measures and permanently records the number of particles suspended in liquids, has been announced by the General Electric Company's Special Products Section, Schenectady 5, N. Y. It can be used with an audible or visible alarm and provides readily available turbidity measurements for monitoring and controlling. Specific applications include chemical and paper plants; monitoring of wastes dumped into streams and lakes to guard against pollution; water treatment plants where turbidity of incoming water determines the amount of flocculation chemicals to be added; detection of oil contamination in boiler feedwater;



soil erosion studies; and in any process where filter effectiveness must be constantly monitored. The theory of operation is that if a liquid has no suspended particles, all light is transmitted while none is scattered so that the ratio of scattered to transmitted light is zero. As turbidity increases more light is scattered, less transmitted and the ratio increases. The turbidimeter's detecting element is a single photovoltaic cell with current output proportional to the amount of light falling upon it. The light ratio is determined by computing the voltage output of the photo cell when scattered light and then transmitted light are incident upon it.

Remote Reading Gage

A convex scale Jerguson Truscale Remote Reading Gage is announced by Jerguson Gage & Valve Co., 80 Fellsway, Sommerville, Mass. The new scale permits full 180 deg visibility so it is possible to read the liquid level from anywhere in the control room from which the gage cover can be seen. It is designed so that readings of the liquid level can be instantly taken from the front, or either side, without distortion. Scale markings are directly on the convex face. Indicator goes clear around the convex surface.

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Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Pyrometer Supplies

Pyrometer supplies are illustrated and described in the newly revised Buyers Guide, 100-5, prepared by Minneapolis-Honeywell Regulator Co. All general thermocouple assemblies and components are listed, as well as many special purpose items. Prices and several pages on selection, care and application of thermocouples round out this 48-page catalog.

Gas Analysis Apparatus

A 48-page catalog published by the Burrell Corp. lists and describes equipment and accessories for gas analysis. The new publication, designated as No. 81, lists many different models and types of apparatus and offers aid for their proper selection. All major items are described in detail and are clearly priced. Five pages are devoted to an offering of laboratory models of gas analyzers which include Burrell's build-up design as well as cabinet models. Another section of ten pages describes seven different portable types.

Air Valves

To describe the functions of their Type AV combination air release and air inlet valve, a 4-page bulletin, No. 1203, has been prepared by the Simplex Valve and Meter Company. This valve was designed for the specific purpose of providing a small unit having the functions of releasing automatically air accumulations from systems, admitting air to systems for the purpose of breaking vacuums within them, and venting large quantities of air when filling systems with water. Pictures of the valve in closed and open positions, general description of the unit, discharge capacities, uses, weights and dimensions are listed.

Motor Starters

Features of Allis-Chalmers Type H starters built to control squirrel-cage, synchronous, wound-rotor and multispeed motors in ratings from 2200 to 5000 volts are described in a new 12-page bulletin, No. 14B6410B, released by the company. The starters in ratings up to 2000 hp at 5000 volts are available with air or oil contactors depending upon application requirements. How these

contactors are made and how they operate is explained in the bulletin. Protection features of the starters—short circuit, overload, time relay undervoltage and pullout protection–are covered in the bulletin, which also carries schematic wiring diagrams showing typical methods of control.

Fire Pumps

Ingersoll-Rand Co. has made available a 4-page descriptive bulletin on its line of horizontal, single-stage and vertical, multi-stage fire pumps. Both types have been approved by the National Board of Fire Underwriters and the Associated Factory Mutual Fire Insurance Companies for permanent installation in fire protection systems of the hose line or sprinkler type. Cross-section views with additional descriptions of the design, construction and performance of these pumps are contained in the bulletin.

Float Valves

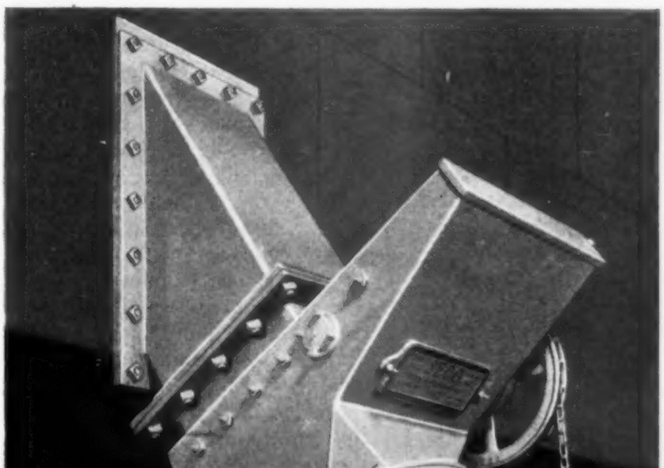
A 16-page catalog, No. 107, describing float and lever valves has been made available by the Schade Valve Manufacturing Co. It shows balanced float valves suitable for liquid level control in open or closed tanks, lever valves for controlling steam and other industrial process fluids, and a series of diaphragm-actuated control valves for handling air or water.

Oxygen Analyzer

Leeds & Northrup Company has published an eight-page folder describing oxygen recording equipment. There are sections on how the paramagnetic principle works, how it is applied to the analyzer and how the resulting signal is handled by the recorder. Other sections of the bulletin cite typical applications, performance characteristics and general specifications.

The Operator With the S-E-Co. Coal Valve

S-E-Co. Coal Valve shown below is Style 2BS, designed for inclined installation. This style features 2" offset between inlet and outlet centerlines and a disc brake to prevent gate from self-closing.



can rely on dependable, easy gate operation because the double racks and pinions prevent gate cocking and binding; the U-shaped gate keeps coal and moisture from operating parts and prevents sticking and wear; roller bearing equipped rollers with pressure greasing and dust-seals support the gate and insure free motion; and the operating shaft is mounted on anti-friction bearings.

Purchase your valve requirements from Stock Equipment Company, where valves are a specialty and receive the attention to design and construction they require. Stock Equipment Company has a full line of valves in sizes ranging from 6" to 42" designed to control coal, soot or siftings, or bulk materials. For bulletin or help on your valve problem, write to

STOCK EQUIPMENT COMPANY
745C HANNA BUILDING
CLEVELAND, OHIO

BOOKS

1—The Technique of Clear Writing

By Robert Gunning

289 pages Price $3.50

The author of this book has had outstanding success as a readability consultant and his firm has conducted readability surveys for the United Press and Newsweek. It has also been responsible for clear writing training for such organizations as Standard Oil of New Jersey, B. F. Goodrich Company and the Baltimore and Ohio Railroad.

Knowing this background, the practicing engineer should approach this practical guide to writing with an idea something like this: he is capable of writing clear and convincing reports if he is only wise enough to apply the outlined principles thoughtfully.

The book opens with chapters telling what has been learned about the habits and preferences of readers. Then follows the second and longest part of the book in which ten principles of clear writing are elucidated. Part three has chapters entitled "The Fog in Your Newspapers," "Business Writing," "Legal Prose" and "Technical Writing."

For the engineer who wishes to write effectively the last chapters mentioned above deserve rereading several times. The author points out that the men of science most venerated are those skilled in communication.

He writes that most technical men and women talk clearly and concretely and are able to explain complex matters to a layman when they speak in oral communication. It is only when they begin to write that they shun simple English and slip into an odd jargon that they consider traditional and wise.

2—Coal Manual for Industry

By A. Wyn Williams

324 pages Price $5.50

This is a very readable, moderately technical presentation of information of interest to anyone having to deal with the purchase, handling and burning of coal.

Starting off with chapters on the physical and chemical properties of coal and the combustion process, the book is then arranged to describe the various conventional coal-firing systems. Later chapters take up problems of air pollution, methods of coal preparation the uses of lignite and anthracite, ways for handling the storing coal, and criteria for its purchase (including elements of typical contract specifications).

For the purchasing agent, the operating engineer who wishes to broaden his knowedge of coal utilization, or the engineering manager whose activities only are occasionally concerned with the design or operation of power plants, this book is to be highly recommended.

3—Handbook of Engineering Fundamentals

Second Edition

Edited by O. W. Eschbach

$5^1/_2 \times 8^1/_2$ Price $10.00

The first edition of this handbook brought out in 1936 established its place in engineering literature. In the present, or second, edition all fourteen chapters have been completely revised and expanded with the result that the total text has been enlarged by about 25 per cent.

The book is the work of some forty contributors, each a specialist in his particular field, under the editorship of Professor Eschbach who is dean of Northwestern Technological Institute, Evanston, Illinois.

Contents, by sections, include mathematical and physical tables; mathematics; physical units and standards; mechanics of rigid bodies; mechanics of deformable bodies; mechanics of incompressible fluids; aerodynamics; engineering thermodynamics; electricity and magnetism; radiation, light and acoustics; chemistry; metallic materials; non-metallic materials; and engineering law.

4—Steam Power Plants

By A. H. Zerban and E. P. Nye

524 pages Price $7.50

Intended basically for junior and senior students who have had some previous work in heat power, the text has three objectives:

1. To utilize fundamental principles of science toward the art of heat power engineering.
2. To bring to the attention of the student the economic factors that influence engineering decisions.
3. To give a general picture of the steam-power equipment of representative manufacturers.

The book includes chapters on power plant cycles, fuels, combustion, steady state heat transfer, furnace heat transfer, steam generators, steam power movers, fluid handling, instruments and controls, and internal combustion power plants.

5—Advanced Mathematics in Physics and Engineering

By Arthur Bronwell

475 pages Price $6.00

In preparing this text which is intended primarily for students in engineering and physics at the senior and graduate level, the author was guided by the following principles:

1. To present a fairly complete explanation of those areas of advanced mathematics which make up the principal analytical methods of physics and engineering.
2. To provide a broad perspective of the physical sciences through an understanding of a few fundamental mathematical formulations in those fields common to engineering and physics.
3. To offer an opportunity to become aware of the strong underlying unity in methods of mathematical analysis in many areas of physics and engineering.

The first five chapters take up complex numbers, infinite series, solutions of ordinary differential equations, and Fourier series. There follow chapters on partial differentiation, vibration phenomena, Lagrange's equations and vector analysis. Subsequent chapters are concerned with wave equation solutions, heat flow, fluid dynamics, electromagnetic theory, functions of a complex variable, and Laplace transformations.

This is a book well worth serious self-study by engineers whose mathematical education ended at the calculus level.

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